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THE SURGICAL TREATMENT OF LOWER LOBE TUBERCULOSIS

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TUBERCULOUS cavities and bronchial stenosis in a lower lobe are now generally considered indications for primary resection. For these cases, pneumothorax is usually found in my opinion to be a "waste of time and loss of function." The advantage of pneumoperitoneum is that it is mainly only a loss of time. In a great number of cases, it is therefore necessary to perform a primary resection to attain a lasting cure.

After a lower lobe resection, we consider it necessary to diminish the thorax in the following cases:

1. When a segment or more from the middle or upper lobe has to be resected at the same time as the lower lobe lobectomy.

2. If palpable tuberculosis is found in the remaining portion of the lung.

3. If an empyema is resected at the same time.

4. When the tuberculous cavity was opened during the operation.

5. If the remaining lung is very emphysematous or fibrotic.

6. If there is significant contralateral tuberculosis. Following these principles only 2 of 21 patients operated upon for lower lobe tuberculosis were left without a space-diminishing procedure. This paper is concerned mainly with the different surgical possibilities of diminishing the size of the thoracic cavity after a lower lobe resection.

A. *Lower Lobe Resection Without Space-Diminishing Procedure.*—After the removal of a lower lobe with only a localized tuberculous lesion to this lobe,

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there is usually no indication for diminishing the size of the thoracic cavity. When both lower and middle lobes are resected and no thoracoplasty performed, the following result was obtained (Case 1, Table I).

TABLE I. LUNG FUNCTION AFTER RIGHT LOWER AND MIDDLE LOBE RESECTION WITHOUT SPACE-DIMINISHING PROCEDURE

CASE NUMBER	RESECTION OF		FUNCTION OF RIGHT SIDE IN % OF TOTAL		YEARS AFTER OPERATION	MOVEMENT OF THE DIAPHRAGM	
	LOBES	RIBS	O_2 UPTAKE	VENTILATION		RIGHT	LEFT
1.—A 22-year-old woman	Right lower and middle lobes	0	26	49	2	1.5 cm.	4 cm.

Conclusion: The remaining overdistended right upper lobe did not show any sign of reactivation after two years and the patient's sputum and gastric washing were negative on culture and guinea pig test. In spite of the overdistention, there was an optimal oxygen uptake of 26 per cent of the total.

Fig. 1.—Case 2. An x-ray taken three years after resection of right lower and middle lobes with a basal thoracoplasty (resection of ribs 10 to 4). Twenty-four per cent oxygen uptake and 34 per cent of the ventilation come from the remaining right upper lobe.

However, there was an abnormally high ventilation on the right side (49 per cent of the total) in proportion to the oxygen uptake. This is an expression of a very uneconomical respiratory work, due to the overdistention with emphysema.

B. *Diminishing the Space From Below.—*

1. *Basal thoracoplasty:* In 3 cases the thoracic cavity was diminished from below corresponding to the resected lobes, or in other words a basal thoracoplasty was performed. The postoperative function of the remaining lung is shown in Table II (Figs. 1 and 2).

TABLE II. LUNG FUNCTION AFTER BASAL THORACOPLASTY AND LOWER LOBE RESECTION

CASE NUMBER	RESECTION OF		FUNCTION OF RIGHT SIDE IN % OF TOTAL		YEARS AFTER OPERATION	MOVEMENT OF THE DIAPHRAGM	
	LOBES	RIBS	O_2 UPTAKE	VENTILATION		RIGHT	LEFT
2.—A 33-year-old woman	Right lower and middle lobes	10 to 4	24	34	3	1.5 cm.	5 cm.
3.—A 21-year-old woman	Right lower and middle lobes	10 to 7	23	33	2	3 cm.	6 cm.
4.—A 26-year-old woman	Right lower lobe	11 to 7	36	43	2	5 cm.	6.5 cm.

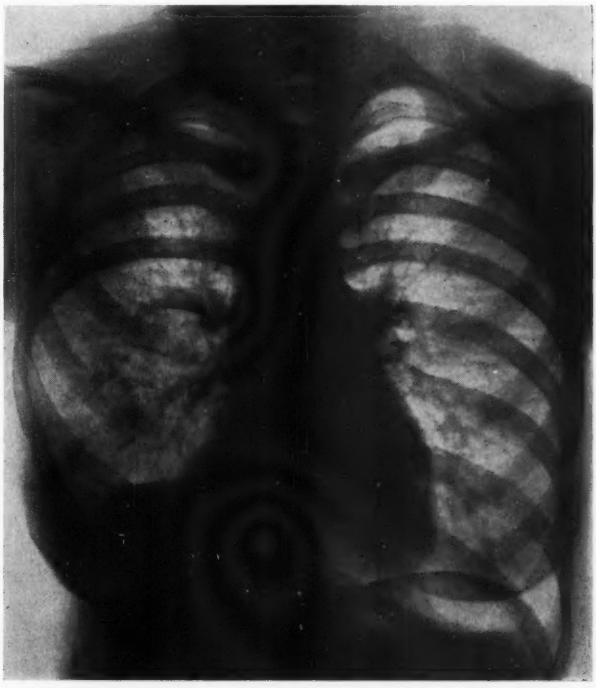

Fig. 2.—Case 3. An x-ray taken two years after resection of right lower and middle lobes with a smaller basal thoracoplasty (resection of ribs 10 to 7) which caused considerable deformity. Twenty-three per cent of the oxygen uptake and 33 per cent of the ventilation come from the remaining right upper lobe.

Conclusion: With the performance of a basal thoracoplasty after a lower lobe resection all 3 patients had negative cultures and negative guinea pig

tests on sputum and gastric washings. An optimal oxygen uptake was obtained by the remaining lung on the operated side at a moderately increased ventilation. Thus, a much more economical respiratory work is obtained as compared with Case 1 in which no space-diminishing procedure was performed. However, a comparatively extensive rib resection had to be performed, resulting in a considerable deformity. After the investigation of these 3 patients, the procedure was abandoned.

2a. *Elevation of the diaphragm by phrenic crush:* To diminish the space after a lower and middle lobe lobectomy by an elevation of the diaphragm seems logical. After such an operation there will be some spontaneous elevation of the diaphragm, especially on the left side. The most simple procedure in order to increase the elevation of the diaphragm is to perform a phrenic crush. This procedure has been used for several years by many surgeons. We are, however, afraid: (1) to impair the patient's ability to raise the sputum in the immediate postoperative period, and (2) to impair lung function by paradoxical movements of the paralyzed diaphragm. Furthermore, emphysema is not prevented as function is regained after six to twelve months.

TABLE III. LUNG FUNCTION AFTER RESECTION OF MEDIASTINAL TUMOR WITH PART OF THE LEFT PHRENIC NERVE

CASE NUMBER	OPERATION	FUNCTION OF LEFT SIDE IN % OF TOTAL		YEARS AFTER OPERATION	MOVEMENT OF THE DIAPHRAGM	
		O_2 UPTAKE	VENTILATION		RIGHT	LEFT
5.—A 15-year-old girl	Extirpation of dermoid with left phrenic nerve	34.1	23.4	5	5 cm.	0 cm.

The loss of function after an irreversible damage to the phrenic nerve is illustrated by Case 5, Table III. Five years after the operation the left diaphragm did not move and only 23.4 per cent of the total ventilation came on the left side. The oxygen uptake, on the other hand, was comparatively much better, i.e., 34.1 per cent of the total in spite of the low ventilation due to the damage of the phrenic nerve. It can be questioned if these values are representative as after the introduction of a Carlens catheter for bronchospirometry, every possibility for pendulum air is excluded, i.e., air, which during expiration, is moving from the right lung over into the left lung. As, however, there was no paradoxical movement of the left diaphragm, it may be assumed that the pendulum air was absent or negligible and therefore the values found at bronchospirometry are considered representative. The drawbacks of an interruption of the phrenic nerve may be avoided by a peripheral mobilization of the diaphragm and a resuturing of the diaphragm with its intact nerve supply at a higher level. I have on several occasions during extrapleural pneumonectomies gone through the diaphragm into the abdomen. The diaphragm has then been resutured at the highest possible level. In one case a pneumonectomy was performed under a 5-rib thoracoplasty. Instead of an extended rib resection, I mobilized the diaphragm and resutured it at the upper border of the sixth rib. The same result would probably have been

obtained more easily by a phrenic crush. After a lower and middle lobe lobectomy, however, I think the mobilization and resuturing of the diaphragm is preferrable to a phrenic interruption.

2b. *Elevation of the diaphragm by mobilization and resuturing at a higher level:* In the above-mentioned cases of extrapleural pneumonectomies the diaphragm with peritoneum was incised and resutured. This is a more rapid procedure than leaving the peritoneum intact. When an elevation of the diaphragm is performed as a planned operation, however, I leave the peritoneum intact in order to diminish the danger of herniation and infection. First an incision is made as peripheral as possible in the diaphragm (Fig. 3). The separation of the diaphragm from the peritoneum is easily performed in the periphery and can be carried in to the centrum tendineum (Fig. 4). The mobilization of the diaphragm is best started posteriorly, where there is no

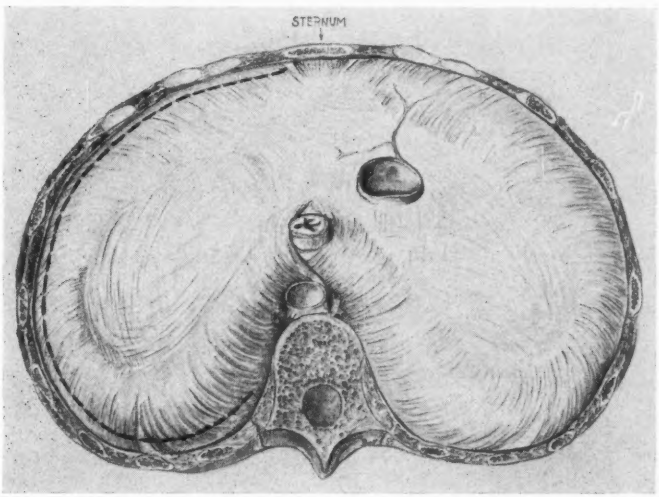

Fig. 3.—The diaphragm is incised in the periphery down to the peritoneum.

danger of opening the peritoneum. The diaphragm is then resutured, either as in Fig. 5*A*, where it encircled the sixth rib and was sutured to itself and to the intercostal muscles. After a subcostal incision under the fifth rib, the diaphragm may be sutured to the fifth intercostal muscle bundle by a row of fine interrupted silk stitches as shown in Fig. 5*B*. The latter method (Fig. 5*B*)

TABLE IV. LUNG FUNCTION AFTER RESECTION OF RIGHT LOWER AND MIDDLE LOBES WITH ELEVATION OF THE DIAPHRAGM BY MOBILIZATION AND RESUTURING

CASE NUMBER	RESECTION OF	FUNCTION OF RIGHT SIDE IN % OF TOTAL		MONTHS AFTER OPERATION	MOVEMENT OF THE DIAPHRAGM	
		O_2 UPTAKE	VENTILATION		RIGHT	LEFT
6.—A 31-year-old woman	Right lower and middle lobes, diaphragm elevation	27.0	32.0	6	0 cm.	5 cm.

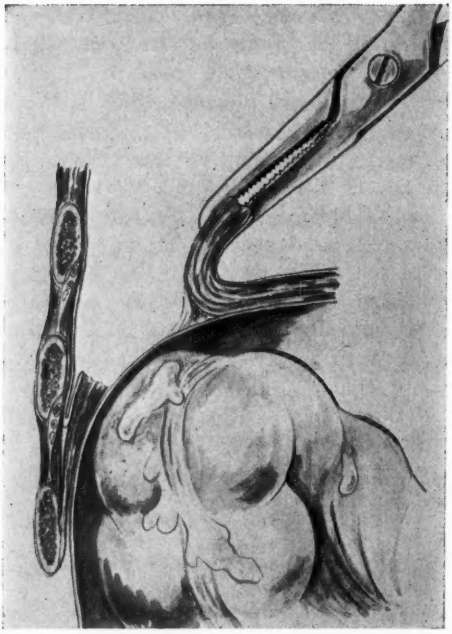

Fig. 4.—The diaphragm is dissected from the peritoneum in to the centrum tendineum.

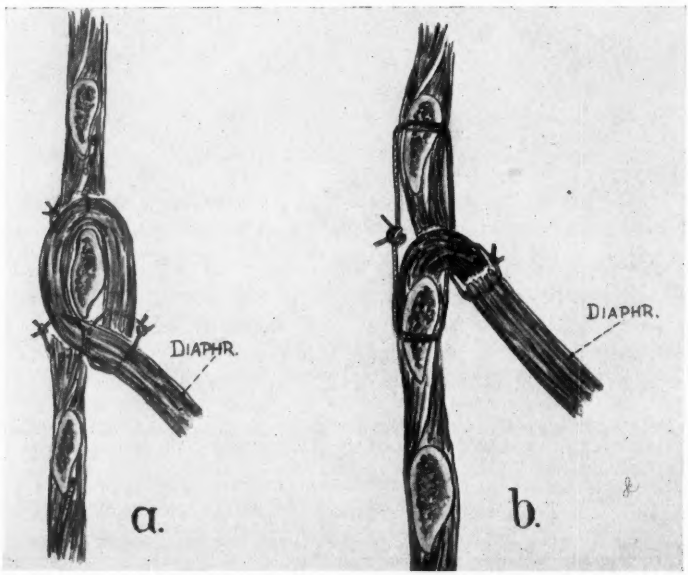

Fig. 5.—The diaphragm is resutured; (a) around a rib, and (b) to an intercostal muscle.

is now preferred. Posteriorly the diaphragm is resutured to the muscles in the intercostal spaces with some heavy nylon sutures being tied around the posterior ends of the ribs (Fig. 6). With intact nerve supply, the resutured diaphragm will act normally in the postoperative period although its excursions are very small. The patients have withstood the procedure well, with an optimum of function and cosmetic result (Table IV, and Figs. 7*A* and 7*B*.) It is difficult, however, to say how much is gained by this more complicated procedure in compari-

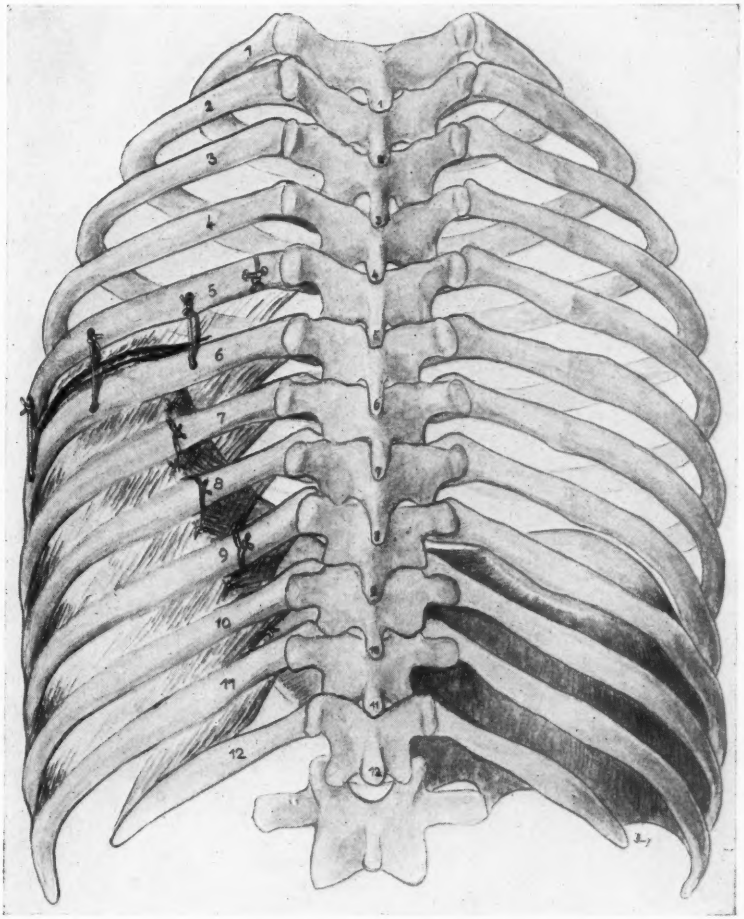

Fig. 6.—Posteriorly the diaphragm is resutured to the intercostal muscles and by sutures tied around the ribs.

son with a simple interruption of the phrenic nerve. In most cases a simultaneous upper osteoplastic thoracoplasty will be preferred. Only in a few cases where there seems to be no danger of infection may an elevation of the diaphragm be considered.

C. *Diminishing the Space From Above.—*

1. *With an apical extrapleural plombage:* In 4 cases the thorax was diminished by an apical extrapleural plombage. After lobectomy through the bed of the sixth rib, an extrapleural pocket was developed through the bed of the fourth rib and filled with plastic material. There has been no sign of infection for more than one year in these cases. As there is an intact and healthy upper lobe between the extrapleural plombage and the resection area with the divided bronchus the danger of infection should be minimal. The

Fig. 7A.

Figs. 7A and 7B.—Case 6. X-rays taken 6 months after resection of right lower and middle lobes with elevation of the diaphragm after mobilization and resuturing.

very bad experience with plombage on the whole has, however, for the time being made me abandon its use even in these cases. Nor has the functional result obtained encouraged me to further use of plombage (Table V).

TABLE V. THE REMAINING LUNG FUNCTION AFTER APICAL EXTRAPLEURAL PLOMBAGE AND LOWER LOBE RESECTION

CASE NUMBER	RESECTION OF LOBES	FUNCTION OF RIGHT SIDE IN % OF TOTAL		YEARS AFTER OPERATION	MOVEMENT OF THE DIAPHRAGM	
		O_2 UPTAKE	VENTILATION		RIGHT	LEFT
7.—A 20-year-old woman	Right lower and middle lobes	16	29	1		
8.—A 25-year-old woman	Right lower lobe	25	36	1	4 cm.	7 cm.

Fig. 7B.—For legend see opposite page.

Conclusion: An extrapleural apical plombage in 4 cases has, after one year, not caused any trouble. The patients had negative cultures and negative guinea pig tests with sputum and gastric washings. The oxygen uptake was, however, lower than in the other groups. No definite conclusion can be made about the functional result from a few cases. It is the bad experience with foreign bodies that has made us hesitate to use this procedure.

Fig. 8.—Case 7. An x-ray taken one year after resection of right lower and middle lobes with apical extrapleural plombage. Sixteen per cent of the oxygen uptake and 29 per cent of the ventilation come from the remaining right upper lobe.

2. *Primary apical thoracoplasty with lower lobe lobectomy at a second stage:* In order to diminish the space of the thorax, first an upper 5-rib thoracoplasty was performed. At a later date, the diseased lower lobe was resected, usually through the bed of the seventh rib. Five cases were treated according to this principle. The postoperative lung function obtained is shown in Table VI.

Conclusion: A good functional result may be obtained by this two-stage procedure. A one-stage operation is, however, always to be preferred. Furthermore, it must be considered wrong in principle to perform a first stage upper thoracoplasty in a case with lower lobe tuberculosis, as the first operation (a) does not close a cavity in a lower lobe, and (b) will cause a more or less pronounced atelectasis of the healthy upper lobe in the postoperative period with shunting of blood through nonventilated alveoli.

TABLE VI. LUNG FUNCTION AFTER PRIMARY APICAL THORACOPLASTY AND LOWER LOBE RESECTION WITH EXTENDED THORACOPLASTY AT A SECOND STAGE

CASE NUMBER	RESECTION OF		FUNCTION OF RIGHT SIDE IN % OF TOTAL		YEARS AFTER OPERATION	MOVEMENT OF THE DIAPHRAGM	
	LOBES	RIBS	O_2 UPTAKE	VENTILATION		RIGHT	LEFT
9.—A 52-year-old woman	Right lower and middle lobes	Stage I 2, 3 Stage II 4-7	25.3	37.7	1	2.5 cm.	4 cm.

From a physiologic point of view this plan of treatment must be considered unsatisfactory and has been abandoned by me.

3. *One-stage lower lobe resection and upper osteoplastic thoracoplasty:* In the last 10 cases of lower lobe tuberculosis in which it has been found desirable to diminish the thorax, an apical osteoplastic thoracoplasty has been performed at the same time as the lung resection.

This procedure is facilitated by operating on the patient in the face-down position with the upper part of the body tilted downward. In this way a subcostal incision under the fifth rib may be used. In this position, the lower lobe is pushed down into the incision by the elevated diaphragm. If the lower pulmonary vein is first divided, the dissection of the lower lobe bronchus and artery is facilitated and there is no danger of damage to the middle lobe structures. When it is decided to complete the operation with a thoracoplasty, the posterior ends of ribs 2 to 4 are also divided to give a better exposure. After completion of the resection, the thoracoplasty is performed in the following way: Posterior parts of ribs 2 to 5 are resected in increasing lengths from above and downward (Fig. 9). Rib 2 is bent in the costal cartilage and fixed with a nylon suture through a drill hole and through the costovertebral ligament and behind the head of the rib on the fifth or sixth vertebra (Fig. 10).

The second rib should, when fixed, be as close to the mediastinum as possible. To obtain a fixation close to the mediastinum it is necessary to make an incision in the cartilage of the second rib near the sternum (Fig. 11). Then a row of 5 to 8 isolated sutures are used to fix the first intercostal muscle bundle to the mediastinal pleura in order to prevent any re-expansion of the lung medial to the new roof. The posterior ends of ribs 3 to 5 are fixed by nylon sutures through drill holes to the posterior end of the sixth rib. One nylon suture anteriorly through drill holes in the fifth and sixth ribs will approximate these ribs and then usually no more sutures are needed for the closure of the chest wall in this plane. It is not necessary to perform an apicolysis. The pleura may be incised at the lateral border of the first rib which is left intact. The mediastinal pleura is then left in place above the new roof. When intact, the mediastinal pleura may be carried down to cover the bronchial stump, the resected area of the lung, and to separate the space above and below the roof. For drainage, two tubes are left intrapleurally and one is left above the new roof. The functional result is shown in Table VII.

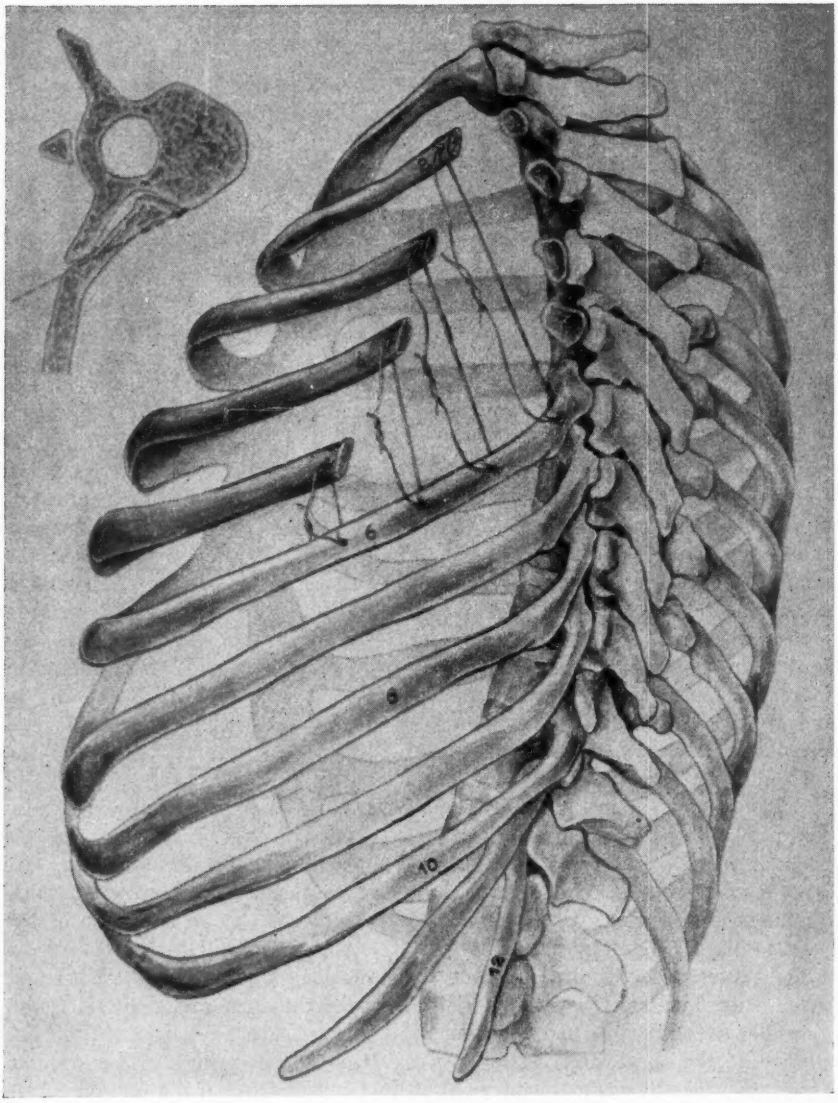

Fig. 9.—Posterior parts of ribs 2 to 5 are resected in increasing lengths from above and downward.

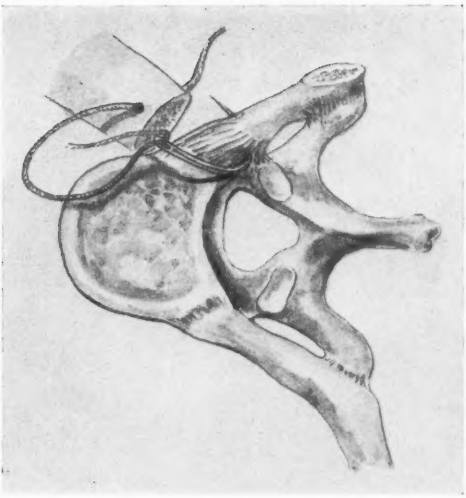

Fig. 10.—A diagram showing the fixation of the second rib with a nylon suture through a drill hole and passed behind the head of the fifth or sixth rib.

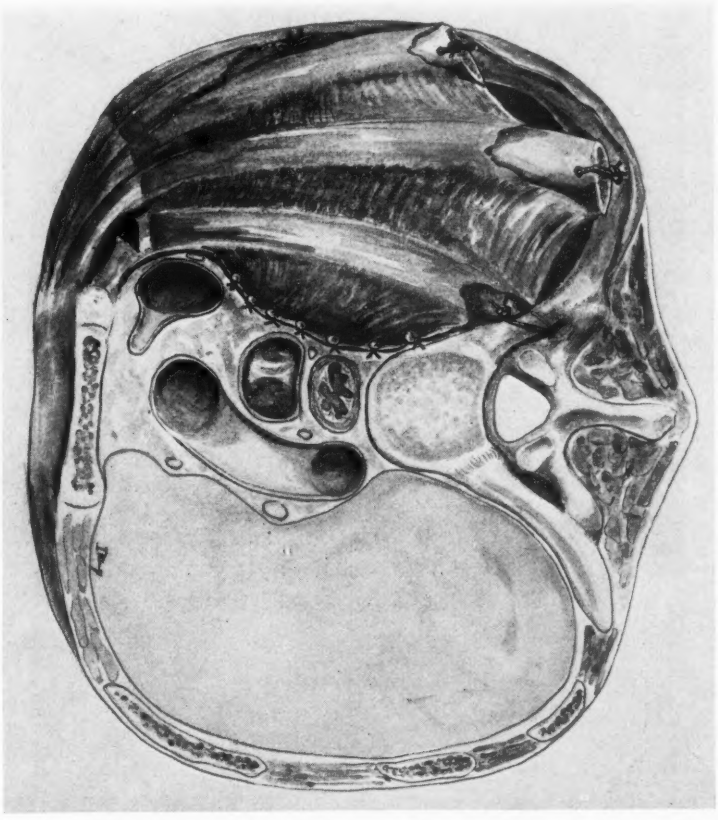

Fig. 11.—The new roof seen from above. The ribs are bent in the costal cartilages and fixed posteriorly by nylon sutures through drill holes. A row of isolated sutures fixes the first intercostal muscle bundle to the mediastinal pleura. Note the incision anteriorly in cartilage of the second rib.

TABLE VII. LUNG FUNCTION AFTER ONE-STAGE LOWER LOBE RESECTION AND UPPER OSTEOPLASTIC THORACOPLASTY

CASE NUMBER	RESECTION OF		FUNCTION OF RIGHT SIDE IN % OF TOTAL		YEARS AFTER OPERATION	MOVEMENT OF THE DIAPHRAGM	
	LOBES	RIBS	O_2 UPTAKE	VENTILATION		RIGHT	LEFT
10.—A 30-year-old woman	Right lower and middle lobes	2-6 fixed on 7th	24.1	34.2	1	5 cm.	6 cm.
11.—A 22-year-old man	Right lower and middle lobes	2-6 fixed on 7th	25.1	38.0	1	4 cm.	6 cm.
12.—A 19-year-old man	Left lower lobe	2-6 fixed on 7th	77.0	77.0	1	8 cm.	5 cm.

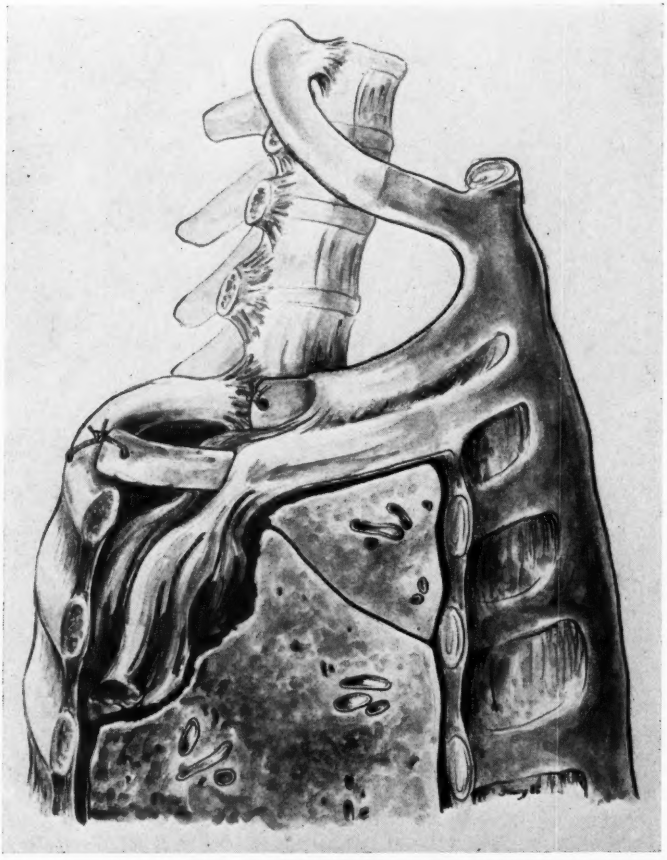

Fig. 12.—A diagram showing the flap of intercostal muscle bundles, which in case of segmental resection is placed directly on the resected area. This muscle flap will diminish the incidence of air leakage from the resected area and make the postoperative treatment easier.

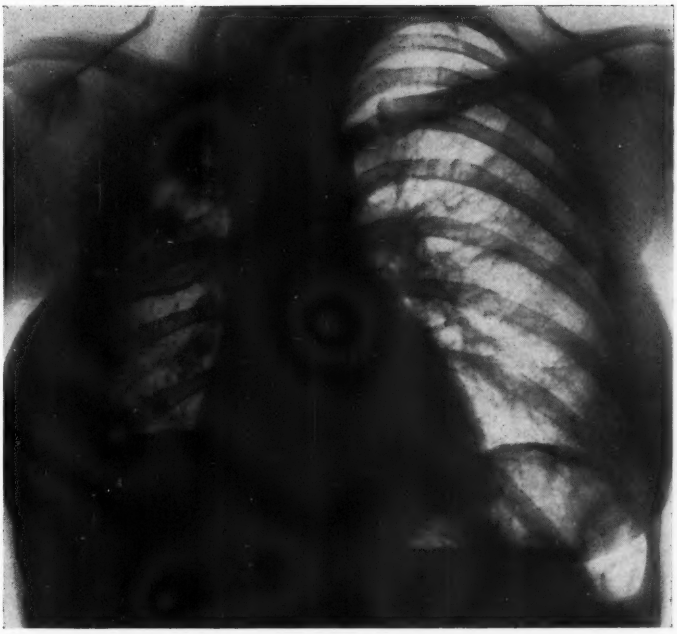

Fig. 13.—Case 10. An x-ray taken one year after resection of right lower and middle lobes with osteoplastic thoracoplasty. Twenty-four per cent of the oxygen uptake and 34 per cent of the ventilation come from the remaining right upper lobe.

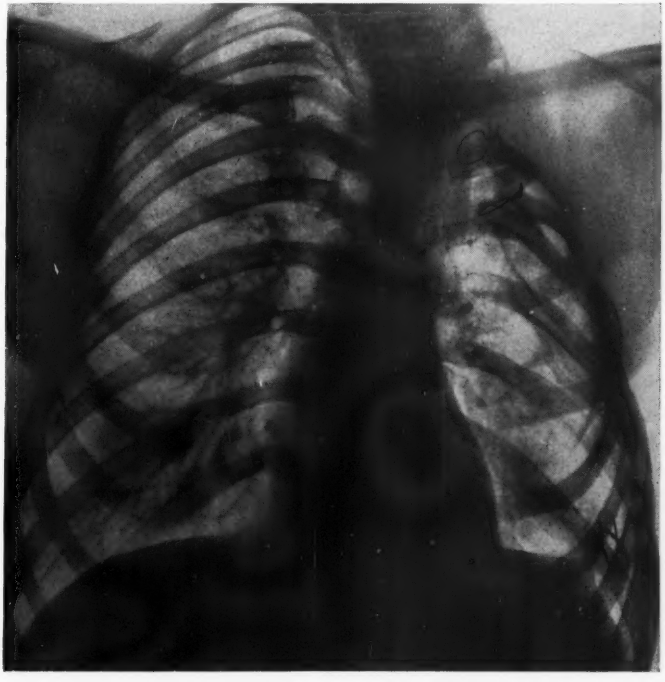

Fig. 14.—Case 12. An x-ray taken one year after resection of left lower lobe with osteoplastic thoracoplasty. Twenty-three per cent of the oxygen uptake and 23 per cent of the ventilation come from the remaining left upper lobe.

Conclusion: In all these one-stage procedures of lower lobe resection with upper osteoplastic thoracoplasty, I used in the beginning the lateral position making the incision through the bed of the sixth rib and making the roof on the seventh rib. In the face-down position, however, a lower lobectomy is easily carried out through the bed of the fifth rib permitting a more horizontal roof with fixation of the ribs to the posterior end of the sixth rib. From a functional point of view the results obtained were as good by this one-stage procedure as in the earlier two-stage procedures. Furthermore, the same function was obtained by this upper osteoplastic thoracoplasty as by the earlier basal thoracoplasties. The cosmetic result after an upper osteoplastic thoracoplasty is, however, far superior, as the deformity is mainly localized to the axilla, and cannot be seen unless the undressed patient lifts the arm.

DISCUSSION

In cases of lower lobe resection where the remaining lung parenchyma is healthy, the chest may be left intact. The resulting overexpansion will increase the minute ventilation and thus the respiratory work for the same oxygen uptake on the side on which the operation had been performed.

A primary basal thoracoplasty will give a good functional result. The severe deformity following such a procedure has, however, made me abandon its use.

Diminishing the thoracic cavity from above, thus displacing the upper lobe downward to the diaphragm, will usually give a good functional result.

A comparatively poor functional result was obtained when an apical extrapleural plombage was used. A plastic plombage placed above a healthy lobe has so far not caused any trouble. The method is, however, at present abandoned in favor of the one-stage lower lobe resection with osteoplastic thoracoplasty, as the latter method seems to give a better functional result. An elevation of the diaphragm will, however, give as good or even better result, but has so far only been used in a few clean cases. (Only the functional values of cases with unilateral disease are given, in which, from a functional point of view, insignificant nodules were found in the remaining lung on the side on which the operation had been performed.)

SUMMARY

In order to diminish the thoracic cavity in cases where this was indicated after a lower lobe resection, a preliminary basal thoracoplasty was carried out. The resulting deformity has prevented further use of this method. Then the remaining upper lobe has been displaced downward by an apical extrapleural plombage and a primary upper thoracoplasty. The method of choice, however, seems to be an upper osteoplastic thoracoplasty performed at the same operation as the lower lobectomy. The face-down position will facilitate resection of the lower lobe through the bed of the fifth rib, making the roof on the sixth rib. Both the cosmetic and functional results seem to be very good

by this one-stage procedure. Only in cases where there is no danger of infection has the diaphragm been mobilized and resutured at a higher level. Then an optimal cosmetic and functional result may be obtained.

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BILATERAL RESECTION IN PULMONARY TUBERCULOSIS

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HITHERTO, patients who became candidates for lobectomy in the treatment for pulmonary tuberculosis were mainly those having a tuberculous focus on one lung only. When pathologic changes existed bilaterally, other methods were used with collapse therapy of the lung.[2, 3] Recently, as lobectomy has become a safe procedure, and as the increased knowledge of pulmonary function has gradually added to the treatment of this disease, unilateral resection with contralateral collapse therapy or bilateral resection has gradually come into use for the treatment of pulmonary tuberculosis. In a rural sanatorium of Japan where I am located, I see quite a number of patients in the outpatient clinic where such treatment is indicated.

Since Eloesser's report[4] in 1932 on bilateral resection, there have been many reports on the treatment of bronchiectasis (Overholt,[5] O'Brien,[6] Kergin,[7] Bisgard,[8] and others). Overholt used this method for the treatment of pulmonary tuberculosis, and since then Chamberlain,[10] Lowell and Conklin,[11] and Shumway and his co-workers[12] have reported nearly a score of such cases.

In Japan, Shinoi[13] and I made separate reports on this problem at the Sixth Annual Meeting of the Japanese Thoracic Surgical Association. In my first case, the patient had large cavities in both of the lower lobes, and artificial pneumoperitoneum was performed for a year without results. Chemical therapy was tried also for several months, without adequate result. Therefore, a bilateral lobectomy on both lower lobes was performed in 1951. Since then I have performed such an operation on 28 patients at the National Okayama Sanatorium. Twenty-two patients who were operated upon by October, 1954, will be reported upon here, and from these results the value of this operation, as well as the preliminary examinations, will be discussed.

SELECTION OF PATIENTS

In performing bilateral resection, the dimension of the lesion, its site, the thickness of the pleural membrane, the movement of the diaphragm, the condition of the bronchi, and the patient's general condition should be considered. A separate bronchospirometric examination for each lung is needed before the operation.

Preoperative Chest X-ray Findings (Figs. 1-5).—In all of the cases reviewed here, the dimension of the lesion was limited to one lobe and the character

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of the lesions were: (a) cavities, (b) localized caseous masses, so-called tuberculomas, and (c) tuberculous bronchiectasis. When they were divided according to the type of case, 7 patients had bilateral cavities (of which one was tuberculous bronchiectasis), 9 had a cavity on one side and localized tuberculous changes on the other, 5 had localized tuberculous changes on both sides, and 1 had an extensive thickening of the pleural membrane. According to the classification of the National Tuberculous Association, 4 cases were far advanced, 12 were moderately advanced, and 6 were minimal (Table 1).

The patients were from 18 to 40 years of age. When they were divided according to sex, 15 were males and 7 were females. The time from the onset of disease to the first operation was 6 months to 6 years, 9 months, an average

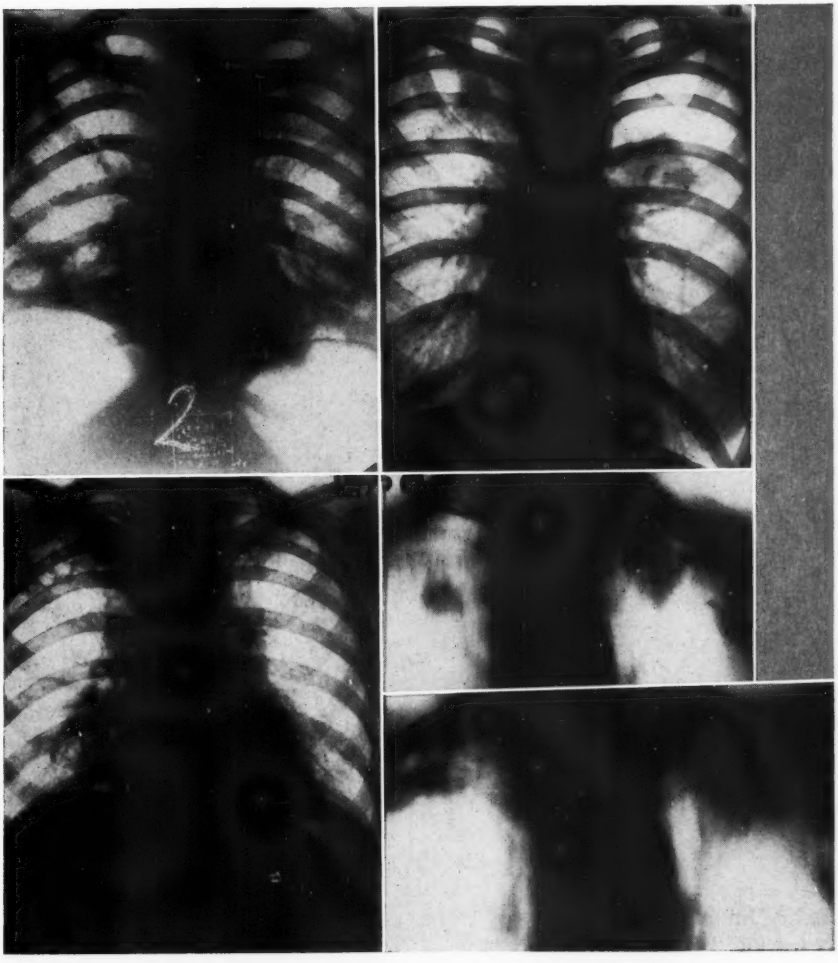

Fig. 1. Fig. 2. Fig. 3. Fig. 4. Fig. 5.

Figs. 1-5.—Preoperative x-ray findings.

TABLE I. INDICATION

	BILATERAL LOBECTOMY	UNILATERAL LOBECTOMY CONTRALATERAL SEGMENTAL RESECTION	BILATERAL SEGMENTAL RESECTION
Far advanced	2	2	0
Moderately advanced	3	4	5
Minimal	0	1	5

of 32 months. The duration of the disease in 8 cases was over 3 years and these patients had generally been under treatment for a long period. Patients whose general condition was critical are omitted from this report. Among these patients, 7 had received artificial pneumothorax and 2 pneumoperitoneum before the operation. In 4, therapy was carried out over a long period of time (over 4 years) with pneumothorax for localized lesions. Other patients were given streptomycin and PAS, or PAS and INH before the operation. They also had the sputa examined by smear or culture for Mycobacterium tuberculosis before the operation. The results, in every case, were positive. In some patients, however, no doubt one lung would have given a negative response if the lungs had been tested separately.

Bilateral resection was indicated in the following cases: (1) Patients who did not respond to collapse therapy (artificial pneumothorax, or pneumoperitoneum), or those in whom the response was doubtful. (2) Those who had hitherto been indicated for thoracoplasty, but who also needed some surgical treatment contralaterally, and where lobectomy seemed to be best because of the respiratory function. (3) Cases where the localized lesion was stable and had a diameter of more than 2 cm.

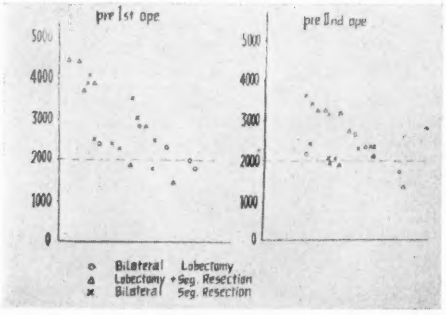

Fig. 6.—Preoperative vital capacity in bilateral resection.

In the composite lung function, the respiratory function should be given differential vital capacity tests and I have always inserted a Carlens double lumen catheter before the first and second operations to study the bronchospirometry of both lungs to see what the residual lung capacity in the function of the contralateral lung was. It is vitally important to know the condition of the lung in order to prevent future postoperative dyspnea and to be able to predict the effect of the operation. The vital capacity seen before the first and second operation is shown in Fig. 6. Most of the patients had a vital

capacity of over 2,000 c.c. and those with a capacity below this figure had been receiving collapse therapy. The latter showed hardly any decrease in the vital capacity after the first operation, and in some there was some increase (Fig. 6, right). There were 2 patients who had simultaneous bilateral segmental resections. Their vital capacity before the operation was 3,500 c.c. in the male and 2,600 c.c. in the female, but no severe dyspnea was observed postoperatively. Bronchospirometry before the second operation is shown in Fig. 7. The residual vital capacity of the operated side after the first operation was nearly always over 700 c.c. though the first operation may have been a segmental resection or a lobectomy and no dyspnea was recognized postoperatively. Breath-holding time was over 20 seconds. Therefore, if the total vital capacity was over 2,000 c.c., and the residual capacity in the contralateral lung during differential vital capacity was over 700 c.c., I assumed that the operation could be performed successfully.

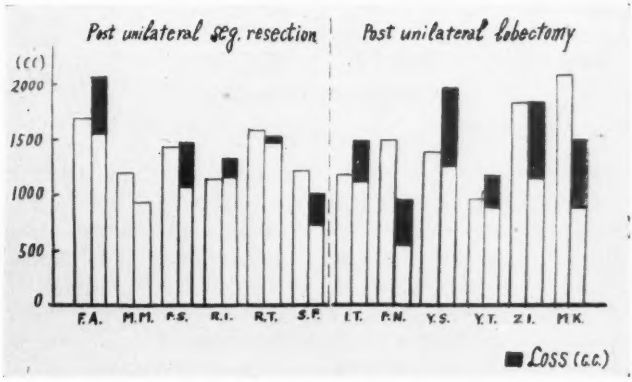

Fig. 7.—Bronchospirometry before second operation.

EXTENT OF RESECTIONS

The limit of the extent of resections in experimental animals is said to be 65 to 78 per cent (Ozawa[1]). Hayashi[19] says that 50 per cent is the limit in the human being. There have been cases reported of bronchiectasis where more than 50 per cent of the lung has been resected (Graham,[20] Overholt,[9] O'Brien[6]). I doubt that the problem should be solved in the same way when the focus of the pulmonary tuberculosis is in the upper lobes. Suzuki[21] and Kergin[7] had the same opinion about this problem. In Lowell's[11] experience with pulmonary tuberculosis, about 40 per cent was the maximum limit. But, in a case of a lobectomy with a thoracoplasty on one side and a decortication with a thoracoplasty on the other, he states that both upper lobectomy with the removal of the left S6 and right middle lobe could be possible.

The limit of resection in our patients is shown in Fig. 8. There were 5 cases where over 7 segments were resected (Group A). Our case of greatest resection was that of the removal of both lower lobes (9 segments and 50 per cent of the lung). In one case, the upper part of the lung was removed, and in

another both upper lobes and the left S6 were resected (8 segments and 44 per cent of the lung removed). After 2 years and 10 months, respectively, these patients are still working without difficulty.

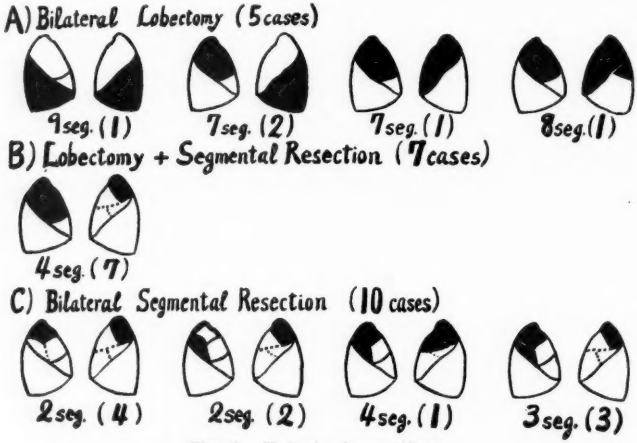

Fig. 8.—Extent of resections.

THE OPERATION

1. *The Method of Operation.*—Due to the problem of preserving pulmonary function and to the advances in chemotherapy, there have been many opinions as to whether thoracoplasty should be performed after segmental resection or lobectomy. In my cases where lobectomy of both upper lobes was performed, obliterative thoracoplasty was not done. When, however, a large cavity existed or the patient had a tuberculous bronchiectasis on one side, a planned thoracoplasty was performed a month before the main resection in order to prevent any postoperative complications.[15, 16] I have found from experience that when there was a tuberculous focus in the left upper lobe, resection of S_{1+2} and S_3 was perferable in many cases to a complete lobectomy.

2. *The Elapse of Time Between the Two Operations.*—There was a period between operations of cases, 3 to 6 months in 7 cases, and under 3 months in 6 cases. When a bilateral resection was planned and if the patient's condition after the first operation was good, it was usually possible to perform the second lobectomy about 4 months after the first one; in cases of segmental resection it was 3 months. Simultaneous bilateral segmental resection, started by Overholt, is possible if the patients are picked carefully according to other factors (Shumway and associates[12]). I had 2 cases where simultaneous bilateral segmental resection (S_1, and S_{1+2}) was performed and the postoperative course was uneventful, without either dyspnea or cyanosis. Both of the patients had fully recovered at the time of their discharge from the hospital. The selection of patients should be done very carefully and the condition of the patient after the first operation should be considered before applying this method. It is best not to prepare for a simultaneous bilateral resection at the beginning.

3. *Picking the Site of the First Operation.*—It is generally believed that the side which has the larger focus should be operated upon first. By removal

of the major focus of the disease, a large contagious focus may be removed which will help the patient to recover function. Furthermore, this would decrease the operative wound on the contralateral side of the lung. When the degree of the disease between both sides is about the same, the anatomic relation and the influence of the cardiac function should be considered and usually the right side is the one operated upon first.

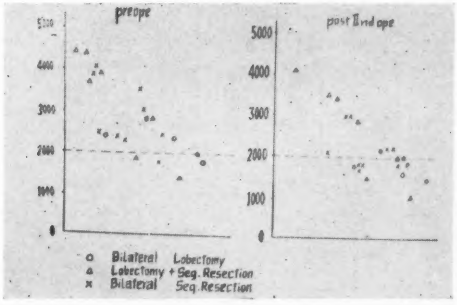

Fig. 9.—Pre- and postoperative vital capacity in bilateral resection.

THE POSTOPERATIVE PULMONARY FUNCTION

As O'Brien,[6] Mannix,[17] and Hayashi[19] have already stated, of all the causes of postoperative disturbances in the pulmonary function, the main danger is from pleural complications. In these, the thorax and its contents, the lung parenchyma, bronchi, and the chest walls are all involved. The postoperative re-expansion of the lung is a more serious problem in bilateral pulmonary resection than in a unilateral resection. The surgeon must also know how much pulmonary function the individual must recover to be able to return to his ordinary life. The operation is only possible when an adequate pulmonary function is assured after the operation. Kano,[3] as a result of his experience in bilateral thoracoplasty, states that a vital capacity of 1,500 c.c. is needed for the individual to lead an ordinary life.

Fig. 9 shows the vital capacity changes before and after operation. There is only 1 case (a woman) where the vital capacity was below 1,500 c.c. after a bilateral pulmonary resection. Most of the patients who had bilateral segmental resection (Group C), and unilateral lobectomy with a contralateral segmental resection (Group B) had a vital capacity of over 2,000 c.c. Their volume loss in vital capacity was smaller than those who had had a bilateral lobectomy (Group A). The volume loss in the vital capacity to that of the preoperative value and the rate of decrease are shown in Fig. 10. In Group A, as the vital capacity was smaller than that of Group B, actually the volume of loss was also small, but the rate of decrease paralleled the amount of resection. Those in Group C, where collapse therapy was performed before the operation (Group $C_{(b)}$) there was rather an increase in the vital capacity after the operation.

When the vital capacity and the maximum breathing capacity were obtained with spirometry, the average value in 12 cases was, respectively, 2,326 c.c. and 60 L. per minute, and the percentage to the predicted normal value was

lower than 70. This was especially low in Group A (Fig. 11). But, this result was higher than those receiving bilateral extrapleural pneumothorax (VC 60 per cent, MBC 50 per cent), or bilateral thoracoplasty (average of 3 cases, VC 30 per cent, MBC 40 per cent), and from the point of pulmonary function it was far better.

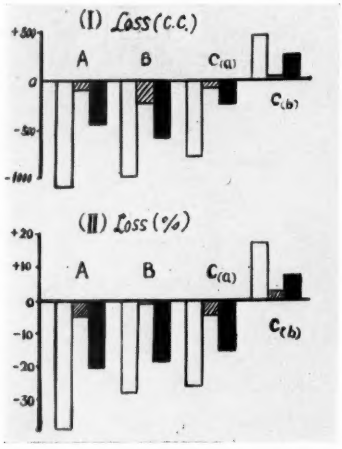

Fig. 10.—Loss of vital capacity with bilateral resection. Maximum ▭; Minimum ▨; Average ■.

BRONCHOSPIROMETRY BEFORE AND AFTER OPERATION

Iwabuchi examined the pulmonary function using a Carlens catheter before and after operation in various kinds of chest operations, and his results for bilateral pulmonary resection are shown in Table II.

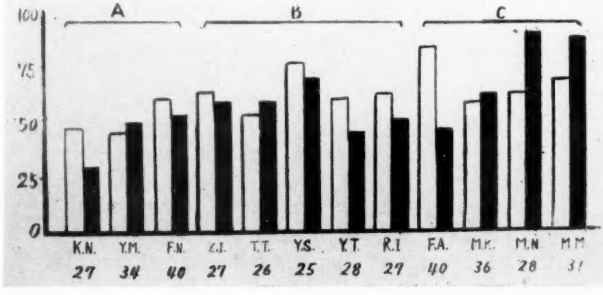

Fig. 11.—Postoperative ventilatory function; MBC and VC, as per cent of predicted (VC average, 2,326 c.c.; MBC average, 60 L. per min.). VC ▭; MBC ■.

There was a decrease in oxygen consumption in all of the groups but there was no significant difference between the three. The decrease in the minute ventilation was especially large in Group A, but in Groups B and C they did not differ much from the value obtained before the operation, showing just a slight decrease. The respiratory count slightly decreased in Group B, but

TABLE II. BRONCHOSPIROMETRY IN PRE- AND POSTOPERATIVE BILATERAL RESECTION

		(A) BILATERAL LOBECTOMY		(B) UNILATERAL LOBECTOMY CONTRALATERAL SEG. RESECTION		(C) BILATERAL SEGMENTAL RESECTION	
		RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT
O_2 Consumption (c.c.)	Pre.	202 (54%)	171 (46%)	174 (53%)	153 (47%)	181 (61%)	119 (39%)
	Post.	178 (61%)	114 (39%)	162 (49%)	171 (51%)	171 (58%)	126 (42%)
Minute ventilation (L.)	Pre.	6.3	4.4	6.6	5.9	6.3	3.9
	Post.	6.3	5.3	6.7	5.8	6.2	3.9
Respiratory frequency	Pre.	18	18	19	19	17	17
	Post.	19	19	23	23	17	17
Ventilation equivalent	Pre.	4.1	4.3	3.8	3.8	3.5	3.3
	Post.	3.5	4.6	4.3	3.6	3.7	3.1
Vital capacity (c.c.)	Pre.	1,847 (52%)	1,473 (48%)	1,783 (52%)	1,677 (48%)	1,405 (63%)	820 (37%)
	Post.	1,417 (55%)	1,143 (45%)	1,250 (50%)	1,277 (50%)	990 (63%)	615 (37%)

Groups A and C were the same as before the operation. The value of ventilation equivalent was about the same as before the operation, and vital capacity paralleled pulmonary resection.

In Figs. 12 and 13 are shown the comparison of vital capacity (tidal volume, expiratory reserve volume, inspiratory reserve volume) and oxygen consumption between the three groups with the results from a typical case representing each group. The ability for each individual to live a normal life after the operation should be judged by his actual mode of life, but as this is quite difficult to do, a load-adding exercise performed after the operation could be used as a gauge. Spirometry before and after exercise is shown in Table III.

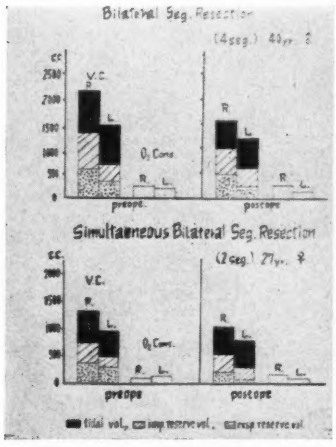

Fig. 12.

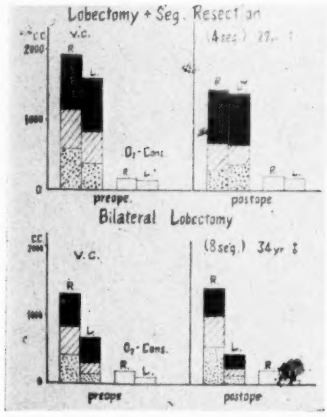

Fig. 13.

Figs. 12 and 13.—Pre- and postoperative bronchospirometry.

and both the oxygen consumption and the minute ventilation were increased in all of the three groups. And in Groups B and C, the value was similar to that of before the operation. The increase in the respiratory rate and pulse rate were below 4 per minute and there was only a slight increase in the ventilation equivalent. MBC increased by 9 L. per minute in Groups A and B, and in Group C it was slight. In other words there was no serious disturbance observed in the pulmonary function before the load-adding exercise.

INFLUENCE ON THE CARDIAC FUNCTION

Tagawa and Numata made an electrocardiographic study of cardiac function before operation and for six months after operation. In the experiment, standard limb leads and unipolar chest leads were used. The changes in the cardiac axis had a tendency to show a right axis deviation immediately after operation. The inverted T_1 and the flatness of T_1 wave were observed. Previously a light myocardiac disturbance was observed in all of the cases (especially in V_1 –V_3 waves) and digitalis was given to 3 patients in whom recovery seemed likely. Immediately after operation, low amplitude, flattened T_3 and inverted T_3 and depressed S –T_3, probably caused by hypoxia, were observed,

TABLE III. POSTOPERATIVE VENTILATORY FUNCTION AT REST AND DURING EXERCISE

	(A) BILATERAL LOBECTOMY		(B) UNILATERAL LOBECTOMY CONTRALATERAL SEG. RESECTION		(C) BILATERAL SEGMENTAL RESECTION	
	AT REST	DURING EXERCISE	AT REST	DURING EXERCISE	AT REST	DURING EXERCISE
O_2 consumption (c.c.)	275	310	265	293	292	304
Minute ventilation (L.)	9.9	11.5	10.0	10.4	11.5	12.0
Respiratory rate	13	17	16	16	17	19
Ventilation equivalent	3.7	3.9	3.7	3.6	4.0	4.2
Vital capacity (c.c.)	1,850	1,825	2,568	2,565	2,670	2,645
Expiratory reserve volume (c.c.)	715	670	793	817	788	805
Tidal volume (c.c.)	560	500	650	674	603	583
Inspiratory reserve volume (c.c.)	635	660	1,125	1,071	1,280	1,258
Maximum breathing capacity (L.)	44.0	53.0	63.1	72.6	63.1	65.2
Pulse rate	83	87	101	105	76	87
Air velocity index	1.1	1.1	1.0	1.2	0.9	1.0

but the patients recovered nearly to normal within four weeks. Six months postoperatively, the readings were improved over what they had been before the operation. Immediately after operation, changes by paradoxical movement were observed, but no disturbance by sinus or auriculoventricular blocks was observed. Six months after the operation the circulation time (arm-tongue circulation time) was measured by injection of lobeline and its minimum time was 5.6 seconds, its maximum 11.8 seconds, and its average 9.5 seconds, which were within normal limits. Six months after the operation the two-step method by Master was performed and an electrocardiogram was taken before and after the exercise; there were no serious changes besides a slight tachycardia (Figs. 14 and 15).

RESULT OF THE OPERATION

The reported results (Lowell and Conklin,[11] Shumway and associates[12] are that bilateral resection was followed by no more complications than unilateral resection (Table IV).

TABLE IV. POSTOPERATIVE COMPLICATION

	LOWELL AND CONKLIN (17 CASES)	SHUMWAY ET AL. (15 CASES)	AUTHOR (22 CASES)
Bronchopleural fistula with empyema	2	0	0
Bronchopleural fistula without empyema	1	0	0
Empyema without fistula	0	0	1
Postoperative exacerbation	2	0	0
Contralateral pneumonia	1	0	1
Cyanosis	0	1 (tracheotomy)	0
Wound dehiscence	0	1	0
Air leak	0	1	0

Our patients were observed for eight to twenty-four months after the operation, and though they need further observation, we are giving the results up to the present time. There have been no postoperative deaths or bronchial fistulas in these cases. There was one case of empyema after the second operation but it was temporary and localized. After treatment by drainage of the thorax, intrathoracal washing, and antimicrobial therapy, the empyema

receded without the need for obliterative thoracoplasty. There was one case of reactivation of the diseased focus in the contralateral side after the first operation and because of this the proposed area for resection in the contralateral side had to be enlarged. The postoperative course of the other patients was without complication. In the culture test after operation, there was only one positive case, the others were negative by smear and culture. The symptoms have receded in 10 patients and they have returned to their ordinary way of life. The remaining patients will be discharged soon to their usual pursuits.

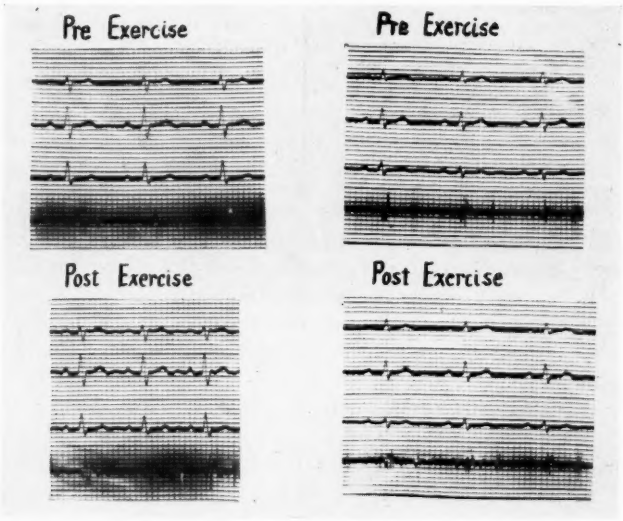

Fig. 14. Fig. 15.

Fig. 14.—Postoperative electrocardiogram of bilateral lobectomy case before and after exercise.

Fig. 15.—Postoperative electrocardiogram of bilateral segmental resection case before and after exercise.

CASE REPORTS

CASE 1.—Bilateral segmental resection. The patient was a 35-year-old man who became ill during the spring of 1953. The preoperative chest x-ray finding is shown in Fig. 16 and dark shadows are seen in both of the upper pulmonary fields. A cavity is seen in the left side. Tuberculous bacterium in the sputum was positive, showing G-6. Vital capacity was 3,900 c.c. Breath-holding time, 60 seconds. Left segmental resection (S_{1+2}, S_3) was performed in September, 1953, and 3 months later a right segmental resection (S_1) was done. The postoperative course was satisfactory and without dyspnea. The postoperative x-ray finding is shown in Fig. 17. Sputum culture gave negative findings. Vital capacity at the time of discharge (8 months later) was 3,600 c.c. Recently during the patient's visit to the outpatient clinic (1 year, 5 months after operation) the vital capacity was 4,100 c.c., which was greater than that before the operation. The man, who is a woodman, is able to go into the forest to cut wood without difficulty.

CASE 2.—Unilateral segmental resection with contralateral lobectomy. The patient was a 25-year-old man in whom symptoms appeared in the spring of 1952. Preoperative x-ray finding is shown in Fig. 18 and a cavity is seen on the right and a localized dark shadow to the left. As the sputum was positive for tuberculous bacterium, the patient desired operation. In November, 1953, a right upper lobectomy with thoracoplasty was

performed and 3 months later a segmental resection was done on the left side, with a satisfactory course. Eleven months after operation, the patient was discharged and is now performing his everyday work without trouble. The postoperative x-ray is shown in Fig. 19, and the present vital capacity is 3,300 c.c. (600 c.c. less than preoperatively). Breath-holding time is 56 seconds.

Fig. 16. Fig. 17.

Figs. 16 and 17.—Case 1. Roentgenograms of a patient who had a bilateral segmental resection. Fig. 16, preoperative; Fig. 17, postoperative.

CASE 3.—Bilateral lobectomy. The patient was a 27-year-old man who developed tuberculosis in 1949. Extensive foci were found in both lung areas and after four years of rest and chemotherapy, the sputa tests were still positive and the patient desired operation.

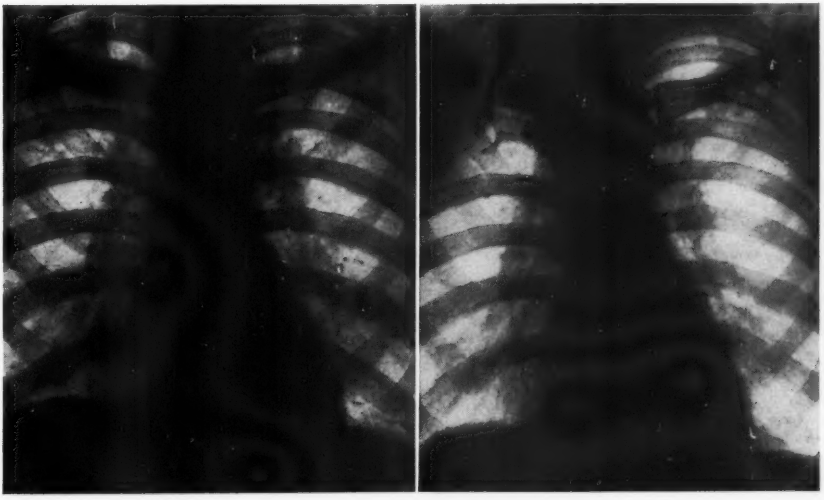

Fig. 18. Fig. 19.

Figs. 18 and 19.—Case 2. Roentgenograms of a patient who had a unilateral segmental resection with contralateral lobectomy. Fig. 18, preoperative; Fig. 19, postoperative.

Preoperative vital capacity was 2,350 c.c. Roentgenogram of the chest is shown in Fig. 20. There was a severe deviation of the mediastinum to the left, the lung appeared contracted, and cavities were seen in both lungs. The patient was not a good candidate for operation, but one was performed as a last resort. Thoracoplasty was not possible because of the pulmonary function, so consultation was held to decide what should be done for the contralateral side after performance of a lobectomy on the unilateral side. Fortunately, the vital capacity was 700 c.c. by bronchospirometry postoperatively on the operated side, so,

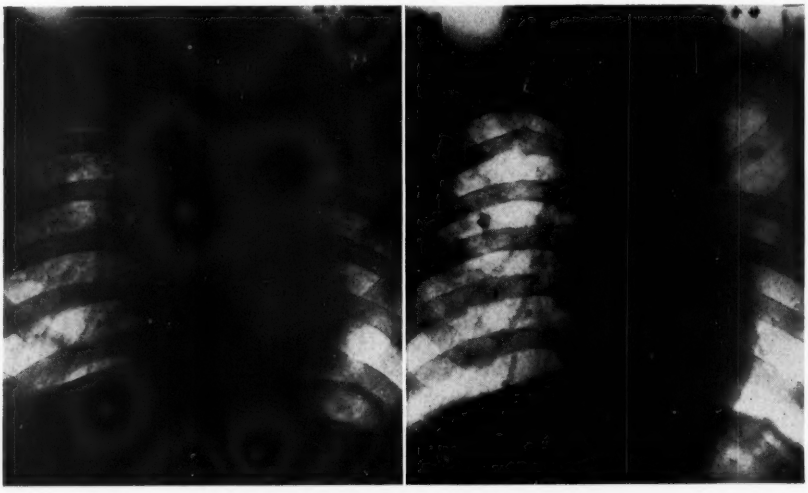

Fig. 20. Fig. 21.

Figs. 20 and 21.—Case 3. Roentgenograms of a patient who had a bilateral lobectomy. Fig. 20, preoperative; Fig. 21, postoperative.

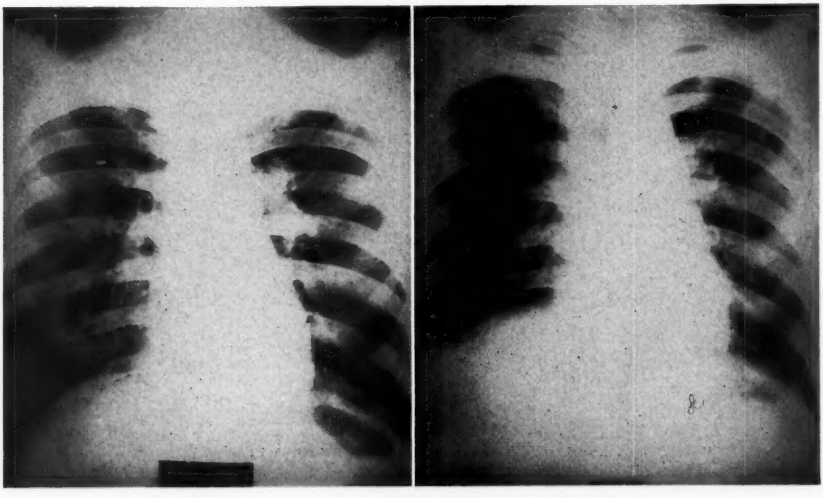

Fig. 22. Fig. 23.

Figs. 22 and 23.—Roentgenograms of a patient who had a bilateral segmental resection. Fig. 22 shows dark shadow in the bilateral apex before operation. Fig. 23 is a postoperative x-ray revealing complete re-expansion without rib resection.

after four months, the second operation was performed. There was no postoperative dyspnea and the patient's course was satisfactory. No tubercle bacilli were seen in the culture or the smear. The vital capacity after both operations was 2,000 c.c. and the breath-holding time was 30 seconds. The postoperative x-ray is shown in Fig. 21. No thoracoplasty was performed. The patient was discharged a year later and is now working as a clerk.

CONCLUSION

We have reported on 22 cases of bilateral resection eight months after operation.

Judging by the postoperative results in these patients and their pulmonary and cardiac functions, if the candidates for operation are picked with care, bilateral resection seems to be successful in returning these patients to their ordinary way of life.

The largest resected area in one case was 8 segments of both upper lobes and the left S6 and 9 segments of both lower lobes. There were no postoperative difficulties.

After a rigid examination, if this method seems adaptable to the case, indication of pulmonary resection can be extended to a greater degree. This would give more hope to these patients.

In closing, we would like to stress the importance of bronchospirometric examination in this type of operation.

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A TECHNIQUE OF PERICARDIECTOMY

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A TECHNIQUE of pericardiectomy is presented which has been used successfully in a number of cases of constrictive pericarditis at this hospital during the past four years.

The outstanding contribution and greatest impetus to us was the transsternal incision described by Julian Johnson. In using and having seen used various other sternal splitting and transcostal incisions on previous cases, great difficulty was encountered due to lack of exposure, particularly in decortication of structures of the right side of the heart.

We used the transsternal approach for the first time in July, 1951, and have become enthusiastic about the incision. The exposure is adequate for extensive decortication of all or any portion of the heart without recourse to second-stage procedures. With an anesthetist experienced in endotracheal anesthesia, this approach is as safe as any other type of incision (Figs. 1, 2, and 3).

The closure is surprisingly easy. The sternum is readily approximated with wire sutures through bone only. As a precaution, in 2 cases, pericostal wire sutures were also used, but this is not usually necessary. In 1 case, three pericostal wire sutures were removed postoperatively due to nodular reaction about the sutures.

The etiology and diagnosis of constrictive pericarditis have been described thoroughly by others, particularly in the classic thesis of Holman. Our preoperative management was similar, tuberculosis being suspected in all cases. It should be emphasized that postoperative treatment for tuberculosis should be intensive and extend over at least a one-year period. One of our first patients had received treatment for only six months postoperatively, and two years after decortication had a reactivation of pulmonary tuberculosis. After intensive therapy, the tuberculosis is arrested again, and the patient has been back at work for one year.

TECHNIQUE

The patient is placed in the supine position, and an endotracheal tube is passed under a combination of local and Pentothal anesthesia. Large-sized polyethylene tubing or 15-gauge needles are placed in the veins of each leg for rapid administrations. A simple infusion is started in the antecubital vein for the administration of procaine or other needed medications. Fluids are kept at a minimum until the decortication is completed. Electrocardiogram

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leads are attached to both arms and legs, using eight-foot extensions. The electrocardiogram writer is kept at the head of the table under the supervision of the medical cardiologist. Continuous tracings are needed so that manipulation may be discontinued for short intervals when irregularities in the tracing occur. It is a distinct aid when decortication is done about the coronary arteries, for a current of injury is immediately seen in the tracing, even on compression only of the artery. This change will soon disappear unless permanent damage has been done.

Fig. 1.

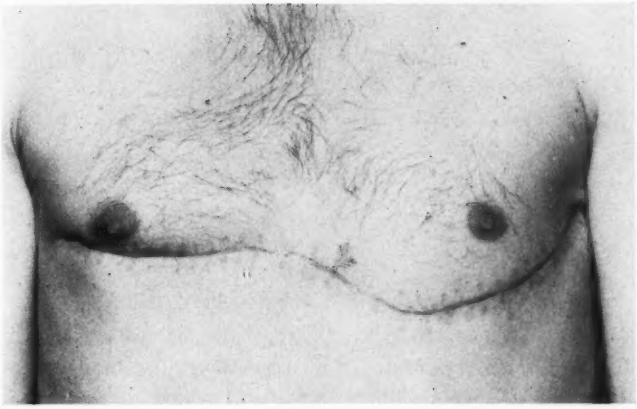

Fig. 2.

Figs. 1 and 2.—Variations in the incision which may be used to meet existing conditions.

After appropriate skin preparation and draping, an intercostal incision is made in the left fifth interspace from the lateral border of the pectoralis

major to the sternum. The left chest and heart are explored and the diagnosis confirmed. The incision is carried over the sternum and into the right fifth interspace to the lateral margin of the right pectoralis major. The right and left internal mammary vessels are identified, ligated, and divided. The attachments of the heart to the undersurface of the sternum (the superior and inferior sternopericardial ligaments) are then dissected. A Gigli saw is passed substernally and the sternum severed at the level of the fifth interspace. The excess tissue of this ligamentous attachment of the heart is excised. This leaves a clear area varying from one to two inches in width where the process of decortication is begun.

An incision just to the left of the midline and longitudinal to it is made with a No. 15 blade knife held obliquely in this "clear" area. The left margin

Fig. 3.—Shows wide exposure afforded by the incision, and the attachments of the superior and inferior sternopericardial ligaments.

is picked up with a small Adson tissue forceps and a line of cleavage developed. In theory, it seems only logical first to decorticate the left ventricle to relieve pulmonary engorgement, which might occur if the right ventricle were dissected first, and to maintain a stabilized systemic pressure. In actual practice, due to ease and safety of decortication, that part of the right ventricle left of the midline is decorticated first. In no case was cardiac failure or pulmonary hypertension noted. Other observers have decorticated the *entire* right heart with similar results. The left ventricle, particularly the apex, is then decorticated before surgery of the remaining right heart. At surgery, the right ventricle and apex, the remaining left ventricle, the right atrium, inferior vena cava, superior vena cava, and left atrium have been constricted to a greater degree in the order named.

In all cases performed, two separate and distinct layers have been found as recorded by other authors. The outer layer will separate rather easily and rapidly with finger dissection. This layer is the greatly thickened fibrous layer of the pericardium and is firmly attached, and may be fused to the central tendon of the left side of the diaphragm. It is much safer, but may be more time consuming, to free and excise this outer layer first since the outline of the coronary vessels becomes visible when it is removed. Cardiac contractions become more forceful and are depicted, in most cases, by increased amplitude of the QRS complex. The right and left heart are freed of this outer layer beyond the border of the phrenic nerves to the coronary sinus on the left and the sulcus terminalis on the right. Both phrenic nerves are freed, cutting away the rind as close to the nerves as safety will permit.

Fig. 4.—Shows the two layers of the thickened pericardium and how the rind is left intact in following the advancing line of cleavage.

The deep layer, though not as thick, is the true adherent and constrictive rind. It is composed of the thickened serous layer of the pericardium. This rind is carefully incised, again just to the left of the midline in the "clear" area, and the correct line of cleavage between the visceral epicardium or cardiac musculature and the rind found and developed. We have observed no fat in this area. This is probably the most difficult and tedious part of the entire procedure. The decortication continues to the left over the right ventricle with

finger dissection developing the line of cleavage. Occasionally a tough band of scar tissue will have to be cut to prevent tearing into a ventricle. If the rind is left intact in following the advancing line of cleavage as described by Bigger, and others, this may be tacked down again should a ventricle be inadvertently opened (Fig. 4). The right ventricle and atrium, of course, is much thinner than the left and we entered it on one occasion. Following the recommended technique, the tear was easily closed with negligible blood loss.

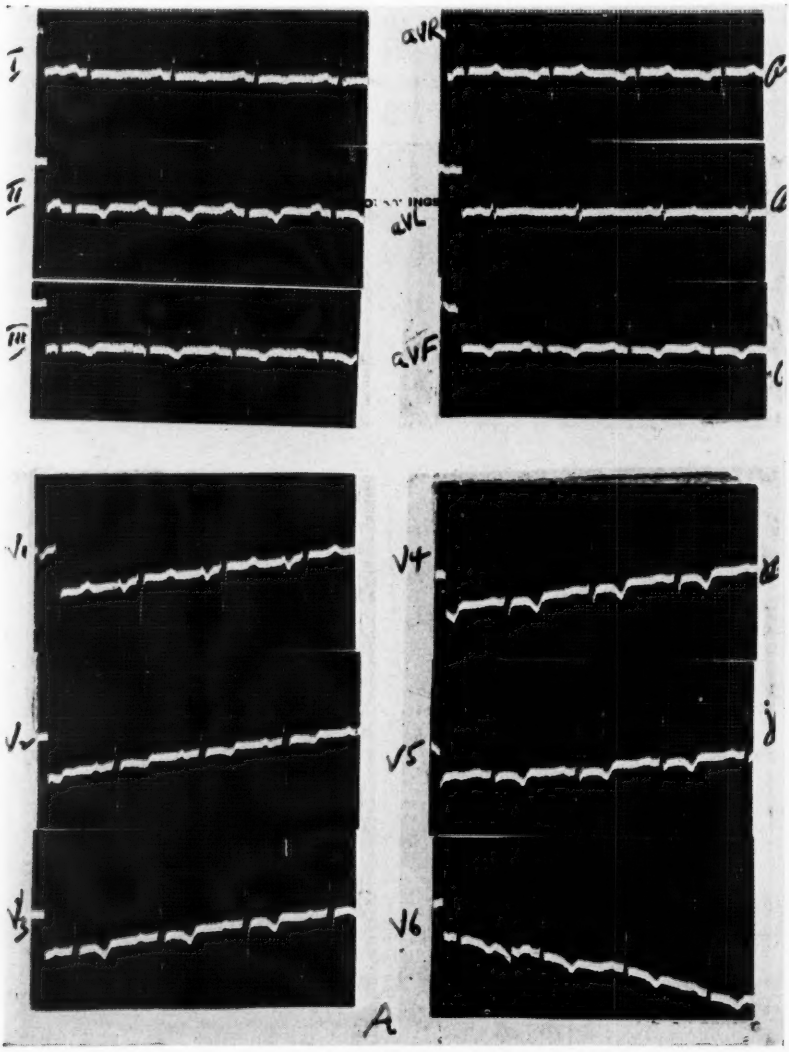

Fig. 5A.—Electrocardiogram before surgery.

This patient, having been bedridden for four months prior to surgery, now drives a large truck for a living, so it is presumed there have been no untoward effects. Electrocardiogram tracings of this patient show only changes consistent with diaphragmatic ischemia (Figs. 5*A* and 5*B*).

As the process of decortication continues, when the interventricular branch of the left coronary is reached, extreme care should be taken because the inner layer may be fused to the wall of the blood vessel. This is particularly true when, after releasing the apex, the posterior and inferior surface of the left ventricle is freed, for it is here that the marginal branch may be damaged. It may be necessary to leave a small band of rind in this area. Decortication continues to the margin of the coronary sinus posteriorly. In our cases, the left auricle has been relatively free of any constriction.

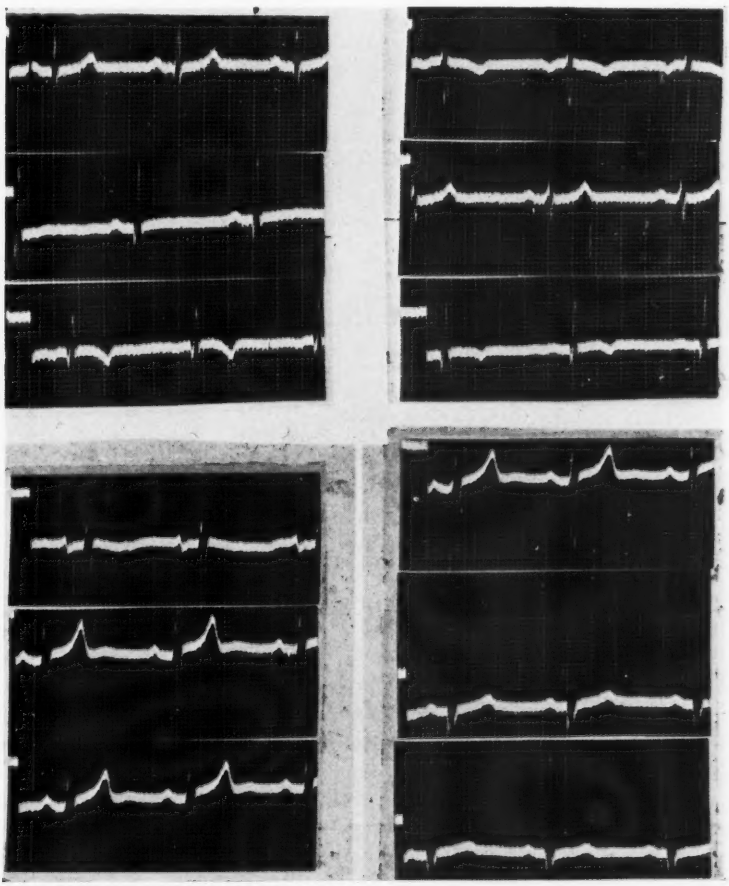

Fig. 5*B*.—Electrocardiogram after surgery. Tracings after surgery show mild changes consistent with diaphragmatic ischemia.

The right border of the inner layer is then picked up and the rest of the right ventricle, right atrium and its appendage is freed to the sulcus terminalis, freeing the superior vena cava and the conus, superiorly.

The inferior vena cava is decorticated last. The rind is tough in this region, and the vessel is friable anteriorly because it is here that the inner layer of the pericardium may be confluent with the wall. Posteriorly, we have found the vessel to be relatively free. This completes the pericardial decortication (Fig. 6).

Fig. 6.—Heart at completion of decortication.

In closing the incision, two holes are drilled through both cut margins of the sternal bone and No. 26 wire passed through to the corresponding side. Interrupted sutures are then taken through the pleura and intercostal muscles, all sutures being held. Appropriate size catheters are then brought out the lateral margins of the incision to drain the right and left chest, respectively. The catheters are connected in the usual fashion to three-way, pressure regulated, underwater-seal bottles and to Gonco suction apparatus.

The rib approximator on each side brings the wound edges together easily and all sutures are tied beginning with the sternal wires. The rest of the incision is closed in layers with interrupted sutures. To complete the procedure, x-rays of the chest are taken while the patient is still on the table to be sure both lungs have been re-expanded. The patient is then moved to the recovery ward for postoperative care (Figs. 7 through 11).

Fig. 7.

Fig. 8.

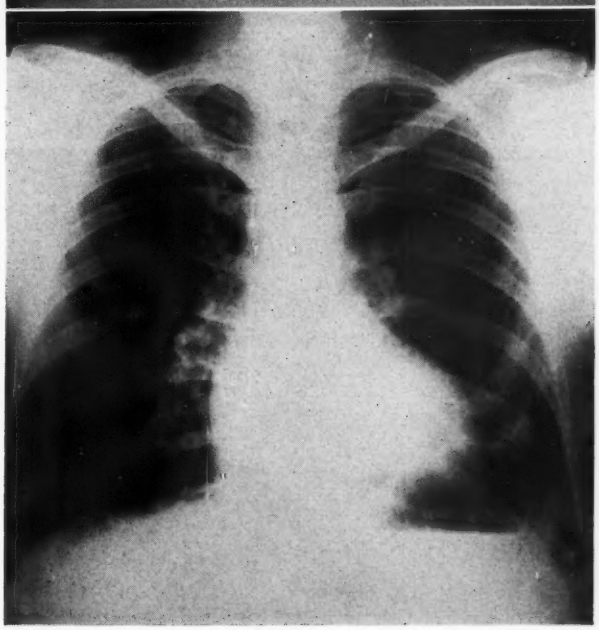

Fig. 7.—Preoperative film of chest in a case of tuberculous pericarditis with ascites and pleural effusion.

Fig. 8.—Postoperative film of same patient taken one year after surgery.

Fig. 9.

Fig. 10.

Fig. 9.—Preoperative views of patient with tuberculous pericarditis.
Fig. 10.—Postoperative films of same patient one and one-half years after decortication.

Fig. 11.—Shows typical tubercle formation in a case of constrictive pericarditis. In this case, tubercle bacilli could not be cultured or found by acid-fast stain. (Tubercle bacilli were found by acid-fast stain in 3 of 10 cases—none could be cultured.)

SUMMARY

1. A technique of pericardiectomy is presented.

2. Decortication is begun in the "clear" area of the heart (the area of the attachments of the superior and inferior sternopericardial ligaments).

3. Rind is left intact in following the advancing line of cleavage as described by Bigger and others.

4. The apex and that portion of the right ventricle to the left of the midline is decorticated first, followed by the left ventricle, and the remaining right heart and great veins.

5. The inferior vena cava is decorticated last.

6. Closure is easy.

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THE SURGICAL TREATMENT OF PULMONARY TUBERCULOSIS IN MENTAL PATIENTS

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INTRODUCTION

THE importance of tuberculosis in mental institutions was recognized in Minnesota as early as 1897 and separate facilities for the isolation of mental patients with tuberculosis were provided at two of the State institutions during the first decade of the twentieth century. However, it was not until 1934 that an effective program for control of this disease in State institutions actually began.[11] That year, Dr. Herbert A. Burns surveyed, by tuberculin test and x-ray examination, all inmates and personnel of the nine State institutions for the mentally ill in Minnesota. His study,[2] showing an inordinately high incidence of tuberculosis among both the patients and those caring for them, led eventually to the establishment of a separate tuberculosis hospital for all mentally ill persons, the Herbert A. Burns Memorial Hospital, which was opened as part of the Anoka State Hospital in 1950.

Since July, 1952, surgical treatment at the Burns Hospital has been carried out in conjunction with the Department of Surgery of The University of Minnesota. Some of our earlier experience in treating these patients has been reported previously.[8, 9, 13] This article is a current summary of our accomplishments in this special group of patients.

The achievement to be realized in treating these patients is less than that attained in patients without mental disease. With few exceptions, these individuals are permanent residents of mental institutions. Nevertheless, most of those who have had pulmonary resections can be removed from the isolation and confinement necessary in a tuberculosis hospital. Furthermore, they no longer threaten the health of other mental patients, the hospital attendants and, indirectly, the population at large.

To achieve these ends, we have felt that it is best to remove surgically all foci which might with time reactivate. Before discharge from the Tuberculosis Unit, it is important that the sputum and gastric cultures of treated patients be consistently negative for in mental hospitals the disease is apt to be contagious. Based on this line of reasoning, our criteria for operation have been more liberal than those usually employed for patients without mental disease. We have

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operated upon all patients in relatively good physical condition if the disease was quiescent and not so widely spread as to prohibit the removal of all significant caseous and cavitary foci.

CLINICAL MATERIAL

To March 1, 1955, 187 patients have had pulmonary resections. All patients have received at least four months of antibiotic therapy prior to surgery, and a total course, both pre- and postoperatively, of at least twelve months. One gram of streptomycin twice a week and 200 mg. of isoniazid daily have been used routinely with para-aminosalicylic acid as a substitute or additional drug in some cases. Bed rest has played little or no part in treatment chiefly because enforced bed rest, among the mentally ill, is not practical.

Age and Sex.—As shown in Table I, our patients have been older on the average (46.6 years) than those in any reported series of patients treated by pulmonary resection.[4, 5, 7, 10, 12] Approximately 40 per cent of our patients were in the fifth decade of life or older. There was a preponderance of men over women in the ratio of 1.35 to 1. Thus, it seems that, at least among mental patients, tuberculosis is characteristically a disease of aging men.

TABLE I. AGE DISTRIBUTION BY DECADES OF PATIENTS UNDERGOING RESECTIONS FOR TUBERCULOSIS (RANGE: 18-73 YEARS)

AGE	NUMBER OF PATIENTS
11-20	1
21-30	20
31-40	37
41-50	50
51-60	56
61-70	21
71-80	2
Total	187

Mortality Rates and Complications.—There were 16 deaths, early and late, in the entire group, an over-all mortality rate of 8.5 per cent. The causes of death are given in Table II. Respiratory complications in the postoperative period have been responsible for the greatest number of deaths. This reflects the difficulty of postoperative management encountered in uncooperative patients. Tracheotomy has been utilized twelve times after operation but despite this and the frequent use of bronchoscopy, pneumonia and atelectasis have been the most common causes of death.

TABLE II. CAUSES OF DEATH IN PATIENTS UNDERGOING PULMONARY RESECTIONS

Atelectasis and pneumonia	9
Empyema, bronchopleural fistula	2
Massive pulmonary hemorrhage	1
Pulmonary embolism	1
Mediastinal flutter (flail chest)	1
Cardiac arrest	1
Cause unknown	1
Total	16

Bronchopleural fistula has also been a troublesome late postsurgical complication. It occurred in 13 patients following unilateral resection and in 1 patient following both sides of a staged bilateral operation. Two deaths have occurred among the patients who have had these fifteen bronchopleural fistulas, a mortality rate for this complication of 13.3 per cent. One of these deaths followed an unsuccessful attempt at closure by a muscle flap transplant and the other death was due to empyema; in this case the bronchopleural fistula was not recognized until autopsy. Among the 13 remaining patients with fistulas, thoracoplasty plus catheter drainage was a successful treatment in all except 3. These 3 required a muscle flap operation for closure after a thoracoplasty had proved inadequate.

Type of Operation.—Unilateral resections were performed on 146 patients and bilateral operations were completed in 41 others (Table III). In the table it will be noted that the mortality rate has been highest among patients who have had a unilateral lobectomy. The explanation of this is not apparent for the causes of death in this group have not been materially different from the causes of death after other pulmonary resections. Unilateral segmental resection has been followed by a more acceptable mortality rate of 3.1 per cent. Still, many of the patients in this group have had multiple segments removed and the incidence of complications has been as high as it was following lobectomy. Indeed, all bronchopleural fistulas except one occurred after segmental resection.

TABLE III. PULMONARY RESECTIONS FOR TUBERCULOSIS

TYPE OF OPERATION	NUMBER OF PATIENTS	DEATHS
I. Unilateral Operations		
Lobectomy	29	10
Wedge	9	1
Pneumonectomy	12	2
Segmental	96	3
II. Bilateral Operations		
Staged	26	0
Simultaneous	15	0
Total	187	16 (8.5%)

Bilateral operations were performed in 26 patients as staged procedures and in 15 patients the disease in both lungs has been extirpated at one operation. In the group with staged bilateral resections the only significant complications were bronchopleural fistula which occurred in 1 patient and residual active endobronchial disease which persists in another. No deaths have occurred among the patients who have had staged bilateral operations.

The technique of the simultaneous bilateral resection has been described previously.[9, 13] Briefly, the chest is opened transternally in the fourth interspace anteriorly and both pleural cavities are entered. The indicated resections are carried out first on one side and then on the other as the table is tilted from side to side. As a rule, this operation has been reserved for patients who require no more than segmental resections bilaterally though 1 patient has had a lobectomy on one side and a segmental resection on the other. With this technique, one operation can accomplish as much as two thoracotomies and the total period of treatment has been greatly shortened. Sternal separation has

been a troublesome postoperative complication but there have been no deaths in the group. There have, however, been two deaths in patients with exploratory operations through the transverse sternotomy incision. Both of these were relatively poor risk patients with bilateral disease in whom the operation was performed with the idea of resecting both sides if it seemed reasonable at the time of surgery. Because of the extent of the disease and the general response of the patients to the operation only one side was resected in each case. Neither died of complications due to the type of incision used. One died of pulmonary embolism while the other died of atelectasis and pneumonia, both on the thirteenth postoperative day.

Thoracoplasty has been employed only as an auxiliary operation. In all, 45 thoracoplasties have been done. On three occasions, extensive, uncontrolled unilateral disease was treated first by thoracoplasty and subsequently by pneumonectomy. Simultaneous thoracoplasty was carried out fourteen times with pulmonary resection and thoracoplasty was added as a second operation to reduce the size of the hemithorax, twenty-eight times. As described above, thirteen of these late operations were performed for bronchopleural fistula. The deaths which might possibly be related to thoracoplasty were four which occurred following lobectomy with simultaneous thoracoplasty.

Results of Treatment.—Table IV shows the present classification of the 171 surviving patients according to the 1950 standards of the National Tuberculosis Association. Of the 8 patients who have active disease, 5 have had persistent activity after unilateral segmental resection, 1 patient has contralateral active disease after pneumonectomy while another developed contralateral spread after lobectomy. The eighth patient has endobronchial tuberculosis after a bilateral staged segmental resection.

TABLE IV. PRESENT STATUS OF DISEASE IN PATIENTS TREATED FOR TUBERCULOSIS BY PULMONARY RESECTION

CLASSIFICATION	NUMBER
Inactive	77
Arrested	86
Active	8
Total	171

Up to March 1, 1955, 64 patients have been discharged from the tuberculosis unit to other mental hospitals, throughout the State. In each instance, all the disease evident on chest x-ray, except perhaps linear fibrotic scars, has been removed and at least six gastric washings, taken in series, have been negative and none have been positive by culture. These discharged patients are followed by chest x-ray at three-month intervals, and three gastric cultures will be taken every six months for the first two years. The frequency of bacteriologic studies thereafter will depend on the clinical and x-ray findings.

DISCUSSION

Although we have used pulmonary resection more frequently than others who have discussed the treatment of tuberculosis in patients with mental dis-

ease,[1, 3, 6, 14, 15, 16] we believe that the results achieved have justified undertaking such a program. Only 8 patients have experienced late spread or reactivation. On the other hand, we have already been able to return 64 patients to nontuberculosis institutions with the expectancy that they will remain free of their disease, and there are, in addition, an equal number of operated patients who await only bacteriologic confirmation of their apparently arrested state. In each instance, there remains no visible pulmonary or other focus of tuberculosis and of the 64 who have been discharged each had at least six gastric washings that have been negative by culture for tubercle bacilli. With the collapse measures that have been performed by others for mental patients with tuberculosis, it is improbable that results this good would have been obtained.

Not all patients at the Burns Hospital can be treated successfully by surgery. Approximately 100, out of a total population of 420 patients, are too old or physically unfit for operation but at the present time there are at least 90 patients awaiting surgery who can be operated upon with the same chance for success as has been achieved among those reviewed here. In addition, newly diagnosed cases are sent to the Burns Hospital so that there will doubtless be a significant number of new patients at least for some time. Most of these new patients will doubtless be candidates for surgery and in time the number of mental patients with active tuberculosis in Minnesota should be reduced to a small irretrievable minimum. Tuberculosis in mental hospitals can be controlled.

The existence of bilateral disease does not constitute a barrier to successful surgical treatment. Except in patients with widely scattered disease in both lungs, bilateral operation may be carried out with reasonable expectancy for success. Those with bilateral apical disease can be treated surgically at one operation.

SUMMARY

1. One hundred and eighty-seven mental patients with pulmonary tuberculosis have had pulmonary resections performed. Of these, 146 patients underwent unilateral operations and 41 have had bilateral resections performed. Fifteen patients have undergone bilateral simultaneous resections.

2. The over-all mortality rate was 8.5 per cent. The difficulties encountered in postoperative management of uncooperative patients have contributed to this mortality rate.

3. Late results of treatment have been good. Of 171 patients who have survived, only 8 can be classified as having active tuberculosis at the present time.

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RECURRENT CARCINOMA IN THE BRONCHIAL STUMP*

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DURING the past twenty years the medical profession has noted a marked increase in its responsibility toward the problem of bronchogenic carcinoma. The change has occurred because of the rising incidence of the disease and the concomitant development of safe and practical thoracic surgery. Today the diagnosis of pulmonary cancer demands an evaluation of operability. The latter, dependent on many factors, may still be questionable at the time of exploration. There may be lymphatic, pleural or chest-wall involvement the complete excision of which remains in doubt even after the resection has been carried out. In addition, the extension of the primary growth in the region of the carina and main bronchi is often difficult to evaluate.

The present study of recurrent carcinoma in the bronchial stump was undertaken with the preceding considerations in mind. It seemed of practical value to determine if neoplastic tissue had been left behind in the remaining bronchial segment, whether the tumor had actually been inoperable from the bronchoscopic standpoint or if other factors might be of importance in the etiology of this type of neoplastic recurrence. Also, the clinical aspects of recurrent carcinoma in the bronchial stump appeared worthy of study.

At the outset it should be noted that the term "recurrent" is used in its unrestricted sense throughout this paper. It will be apparent from an analysis of results of this study that whereas some of the cases are not examples of recurrent carcinoma in the limited connotation of that word, there are others in which the term is strictly applicable. The similar clinical pattern of all the cases justifies the common grouping.

METHOD OF STUDY

Six hundred and thirty-one patients underwent resection, either lobectomy or pneumonectomy, for carcinoma at the Mayo Clinic prior to September, 1952. In this group there were 18 in whom recurrence of carcinoma in the remaining bronchial stump subsequently developed. These latter cases form the basis of this report. They were studied from the clinical standpoint with

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regard to the symptoms, signs, and diagnosis of recurrence and pathologically, with regard to the extent of the lesion at the time of pulmonary resection.

The clinical histories and surgical records were reviewed. In addition, a study was made of each formalin-preserved operative specimen. The presence or absence of lymph-node involvement was noted. In the gross specimens the distance was measured from the proximal end of the severed bronchus to the nearest visible tumor. Then serial longitudinal blocks were cut from the entire bronchial circumference adjacent to the proximal limits of the tumors. From these blocks, hematoxylin and eosin stained preparations were studied for evidence of microscopic extension of the bronchogenic carcinoma in the mucosa or submucous layers toward the proximal end of the resected bronchus. Particular attention was paid to cellular detail in the bronchial mucous membrane.

RESULTS OF THE STUDY

With few exceptions the clinical pattern in this series was similar for all cases. After resection of a bronchogenic carcinoma these patients returned to the clinic at intervals varying from 5 weeks to 24 months with either cough or hemoptysis or both. In all but 3 cases the recurrent tumor was visualized bronchoscopically and confirmed by biopsy or smear. The diagnosis in 1 case was established by cytologic study of secretions aspirated directly from the bronchial stump and in 2 cases by the finding of malignant cells in the sputum.

The status of the patient up to the time when this paper was written is known in thirteen instances. Of the 11 patients known to be dead, 10 succumbed to the cancer at intervals varying from 3 to 28 months following pulmonary resection. One patient died, apparently of cardiac failure and pulmonary edema, following a transurethral prostatectomy done elsewhere 26 months after pneumonectomy. One patient is known to be alive and asymptomatic 30 months after pneumonectomy and 6 months following diagnosis of bronchial-stump recurrence and treatment with deep roentgen rays and locally implanted radon seeds. One patient is living but in failing health 16 months after resection.

In all instances the tumors were high-grade (Broders) squamous-cell carcinomas. Most of the primary tumors were relatively large, the average being 3.8 cm. in the largest dimension. The size, however, varied from 1.5 cm. to 6.0 cm. in diameter. Lymph nodes were involved by metastasis in 12 of the cases.

On the basis of pathologic findings in the proximal resected bronchus, the cases in this series have been placed in five groups.

Group 1.—This group consists of 5 cases (Table I) in which examination revealed carcinoma at the proximal end of the resected main bronchus. In addition to the bronchial involvement metastatic hilar lymph nodes were present in 4 of the 5 cases. The tumor was on the right side in 3 cases and on the left in 2. Total pneumonectomy and complete hilar-node dissection were carried out in each instance. Three of the operations, however, were con-

sidered at the time of surgery to be merely palliative either because of gross involvement of lymphatic and mediastinal structures or because it became evident as the operation progressed that the main bronchus was involved so near the carina that resection with an adequate margin was impossible.

Three of the five tumors in this group were visible bronchoscopically prior to resection. Biopsy via the bronchoscope produced positive results in 2 of these 3 cases. In the other 2 cases there were bronchoscopic findings, only in retrospect, suggestive of tumor. In one of these biopsy was not done and in the other results of biopsy were negative.

TABLE I. SUMMARY OF DATA FOR CASES IN GROUP 1

CASE	PREOPERATIVE BRONCHOSCOPY	OPERATION	CONSIDERED PALLIATIVE?*	LYMPH-NODE INVOLVEMENT	INTERVAL: RESECTION TO RECURRENCE (MONTHS)	RECURRENCE DIAGNOSED BY:	INTERVAL: RESECTION TO DEATH (MONTHS)
1	Granulations in left upper lobe Biopsy not done	Left pneumonectomy	No	Yes	7	Bronchial secretions	23
2	Tumor in left main bronchus Biopsy negative	Left pneumonectomy	Yes	Yes	4½	Biopsy	9½
3	Tumor right upper lobe and main bronchi Biopsy positive	Right pneumonectomy	Yes	No	1¼	Cells in sputum	3
4	Narrowed right upper lobe bronchus Biopsy negative	Right pneumonectomy	Yes	Yes	4½	Biopsy	14
5	Tumor bifurcation right main bronchus Biopsy positive	Right pneumonectomy	No	Yes	5	Biopsy and smear	19

*Operation considered palliative at conclusion of resection.

In this group of patients the presence of residual carcinoma in the bronchial stump became apparent quite early. There was recurrent cough and hemoptysis within an average of 4.4 months postoperatively in all cases.

Complete follow-up data are available for the 5 cases. The longest interval from the onset of bronchial-stump symptoms to death was 16 months, and the shortest period was 2 months with an average of 9.3 months. The longest survival after pulmonary resection was 23 months and the shortest was 3 months with an average of 13.7 months from pneumonectomy to death. In the 3 cases for which operation was considered at the time to be merely palliative, the average survival period after resection was 8.8 months.

TABLE II. SUMMARY OF DATA FOR CASES IN GROUP 2

CASE	PREOPERATIVE BRONCHOSCOPY	OPERATION	CONSIDERED PALLIATIVE?*	LYMPH-NODE INVOLVEMENT	MARGIN OF RESECTION (CM.)	INTERVAL: RESECTION TO RECURRENCE (MONTHS)	RECURRENCE DIAGNOSED BY:	INTERVAL: RESECTION TO DEATH (MONTHS)
6	Infiltration left upper lobe bronchus Biopsy negative	Left pneumonectomy	No	Yes	1.0	13	Biopsy	Unknown
7	Lesion 1.5 cm. from carina Biopsy positive	Right pneumonectomy	No	No	1.3	10	Biopsy and smear	Unknown
8	Lesion right main bronchus Biopsy positive	Right pneumonectomy	No	No	0.3	3	Biopsy	13
9	No lesion seen Biopsy negative	Left pneumonectomy	No	No	0.6	21	Biopsy and smear	26
10	No tumor seen Biopsy not done	Right middle and lower lobectomy	Yes	Yes	1.0	20	Biopsy and cells in sputum	27
11	Tumor right lower lobe and main bronchi Biopsy positive	Right pneumonectomy	No	Yes	1.3	24	Cells in sputum and biopsy	Living 30 months after resection
12	Tumor left lower lobe bronchus Biopsy positive	Left pneumonectomy	No	Yes	1.0	10	Cells in sputum and biopsy	Living but in failing health 16 months after resection

*Operation considered palliative at conclusion of resection.

Group 2.—There were 7 cases in this study in which examination of the resected bronchi revealed an inadequate margin of resection and metaplasia of the bronchial mucous membrane proximal to the tumor (Table II). In view of the work of Griess, McDonald, and Clagett, a margin of 1.5 cm. of proximal tumor-free bronchus was considered adequate. This problem will be discussed in a later section. The finding of metaplastic epithelium in the bronchi, proximal to the primary tumors, is believed to be significant and will also be considered in more detail later.

The length of resected bronchus proximal to the tumor varied from 0.3 cm. to 1.3 cm. in the 7 cases in Group 2. There was epithelial metaplasia of the proximal tumor-free bronchus in all instances. This finding is illustrated in Figs. 1 and 2, *a* and *b*. In 4 cases hilar lymph nodes were involved by metastases. The size of the primary tumors in this group varied from 1.5 cm. to 6.0 cm. in the largest dimension.

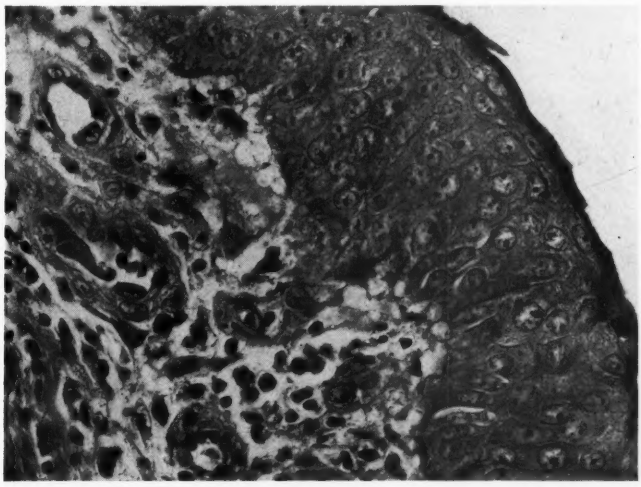


Fig. 1.—Longitudinal section of main bronchus proximal to the primary tumor in a Group 2 case. This demonstrates marked squamous metaplasia of the bronchial epithelium in this region (hematoxylin and eosin stain; ×450).

The tumor involved the right lung in 4 cases and the left in 3. Total pneumonectomy and hilar-node dissection were performed in 6 cases. Palliative resection of the right middle and lower lobes was performed in 1 case because of extensive lymphatic involvement and fixation of the tumor in the region of the azygos vein, vena cava, and pulmonary artery.

Five of the seven tumors in this group were visible bronchoscopically prior to resection. Biopsy was positive for carcinoma in four instances.

The average time from resection to the onset of symptoms of bronchial-stump recurrence was somewhat over 14 months.

Follow-up data are complete for only 4 cases in this group. The interval from resection to death varied in 3 cases from 13 months to 27 months with

an average of 22 months. The interval from the first symptom of stump recurrence to death averaged 7 months. The fourth patient is known to be living and asymptomatic 30 months after pneumonectomy and 6 months after stump recurrence was diagnosed and treated with deep x-rays and locally implanted radon seeds.

Group 3.—Table III summarizes data for the 2 cases in this group. The margin of bronchial resection was inadequate (less than 1.5 cm.) in each.

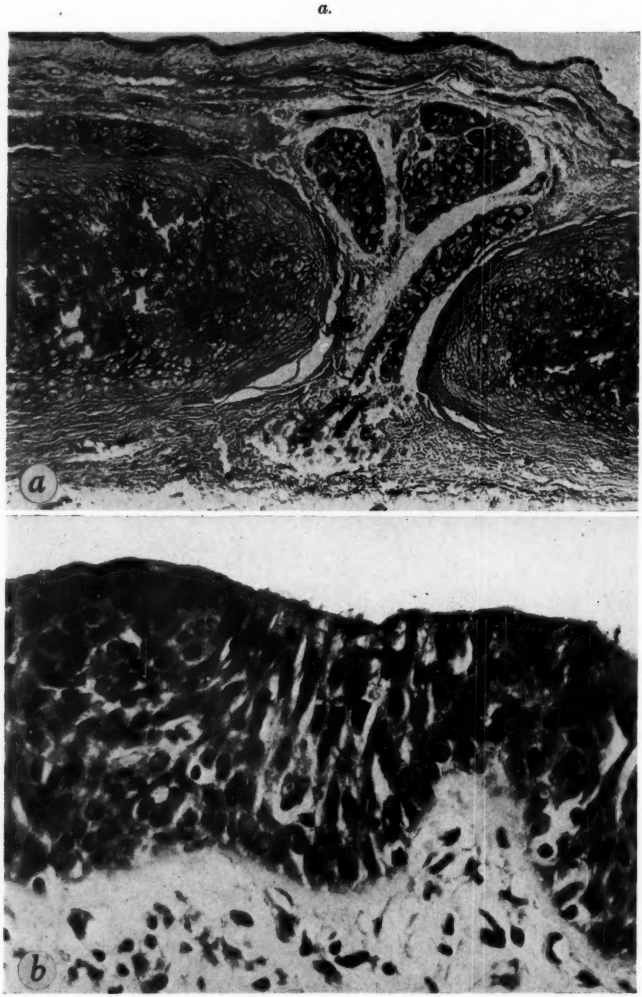


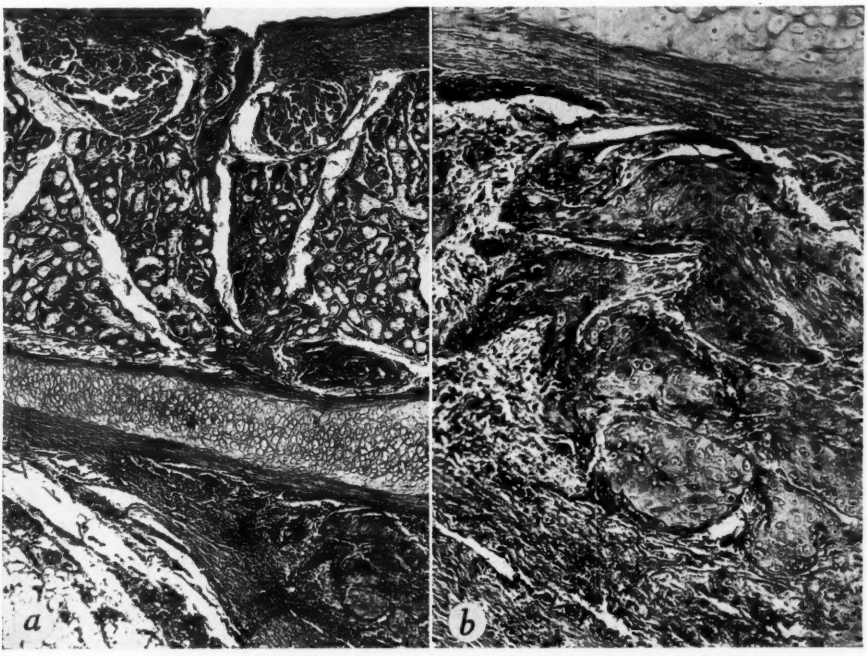
Fig. 2.—*a.* Longitudinal section at the proximal end of the resected main bronchus in another case in Group 2. The mucous membrane at the upper margin of the section is illustrated in higher magnification in *b* (hematoxylin and eosin stain; ×30). *b.* Higher magnification of the bronchial epithelium in *a.* This illustrates a rather early degree of cellular metaplasia in the bronchial mucous membrane (hematoxylin and eosin stain; ×450).

TABLE III. SUMMARY OF DATA FOR CASES IN GROUP 3

CASE	PREOPERATIVE BRONCHOSCOPY	OPERATION	CONSIDERED PALLIATIVE?*	LYMPH-NODE INVOLVEMENT	MARGIN OF RESECTION (CM.)	INTERVAL: RESECTION TO RECURRENCE (MONTHS)	RECURRENCE DIAGNOSED BY:	INTERVAL: RESECTION TO DEATH (MONTHS)
13	Lesion superior wall left main bronchus Biopsy positive	Left pneumonectomy	No	Yes	0.75	5	Biopsy	Unknown
14	Tumor right upper lobe Biopsy positive	Right pneumonectomy	Yes	Yes	?	22	Cells in sputum and biopsy	28

*Operation considered palliative at conclusion of resection.

They differ, however, from the cases in Group 2 in that no epithelial metaplasia could be demonstrated in the bronchial mucous membrane proximal to the tumor. In 1 case preoperative bronchoscopic examination revealed a squamous-cell carcinoma on the superior wall of the left main bronchus. Pneumonectomy was carried out and study of the lung showed that the tumor extended in the outer fibrous layer (Fig. 3, *a* and *b*) to within 0.75 cm. of the proximal extremity of the resected left main bronchus. One hilar lymph node was metastatically involved. Symptoms of stump recurrence appeared 5 months postoperatively, and the patient was thereafter lost to follow-up.



a. *b.*

Fig. 3.—*a.* Longitudinal section of the proximal main bronchus in a Group 3 case. This is an example of tumor extension in the submucosal layers of the bronchial wall. The area in the lower right corner represents tumor in the outer fibrous layer and is illustrated in *b* under higher magnification (hematoxylin and eosin stain; ×35). *b.* Higher magnification of the area in the lower right corner of *a* showing microscopic extension of tumor toward the proximal end of the resected bronchus in this case (hematoxylin and eosin stain; ×110).

In the second case in this group, bronchoscopy prior to operation revealed a squamous-cell carcinoma obstructing the right upper lobe bronchus. At operation the right main bronchus was resected near the carina, but on examination it was found that the tumor extended to the proximal end of the specimen. Accordingly, all the rest of the main bronchus was removed. The exact margin of resection is not known but is believed to have extended inadequately above the tumor. One hilar node was involved by carcinoma.

Symptoms of stump recurrence did not develop until 22 months postoperatively. Death occurred 28 months after the palliative resection. Necropsy is reported to have shown the tumor to be confined to the right hemithorax, mediastinum including the esophagus and heart, and the region of the carina. There were no grossly apparent distant metastases, and no involvement of the contralateral lung was noted.

Group 4.—The fourth group in this series (Table IV) consists of 3 cases in which the main bronchus was resected at least 2.5 cm. above the primary tumor. Recurrence of the malignant lesion became apparent in all cases within 6 months. The significant pathologic finding, in addition to the adequate margin of resection, was a high degree of epithelial metaplasia in the bronchial mucous membrane proximal to the tumor (Fig. 4). Hilar lymph nodes were involved by metastasis in 2 of the 3 cases. Bronchoscopic examination prior to resection produced positive evidence of carcinoma in 2 cases. In the third case, there was an area of questionable infiltration in the left main bronchus, biopsy of which was negative.

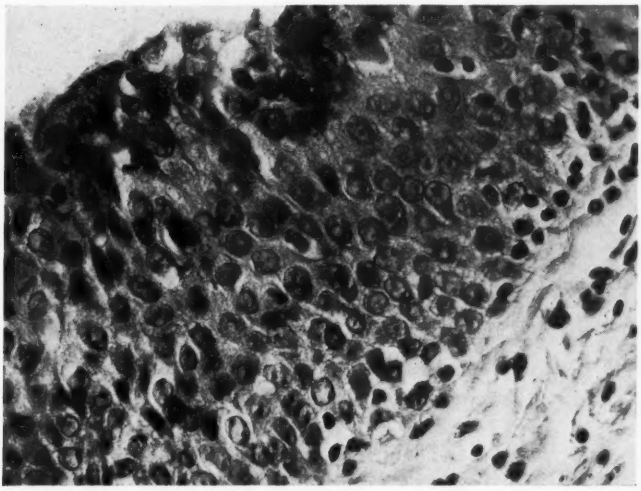


Fig. 4.—Longitudinal section of the proximal main bronchus in a Group 4 case. This is another example of cellular metaplasia at the proximal end of a resected bronchus (hematoxylin and eosin stain; ×450).

In 1 case preoperative bronchoscopy revealed an area of ulceration around the left anteromedial basal-segment bronchus. Biopsy of this was reported grade 4 squamous-cell carcinoma. Total left pneumonectomy and hilar-gland dissection were carried out. The primary tumor was relatively small, 2.5 by 2.0 by 2.0 cm. There were no evident lymphatic metastases, and the main bronchus had been resected 2.5 cm. proximal to the tumor. Six months postoperatively persistent cough and hemoptysis developed. Two months later (8 months following pneumonectomy) hoarseness was noted and a broncho-

TABLE IV. SUMMARY OF DATA FOR CASES IN GROUP 4

CASE	PREOPERATIVE BRONCHOSCOPY	OPERATION	CONSIDERED PALLIATIVE?*	LYMPH-NODE INVOLVEMENT	MARGIN OF RESECTION (CM.)	INTERVAL: RESECTION TO RECURRENCE (MONTHS)	RECURRENCE DIAGNOSED BY:	INTERVAL: RESECTION TO DEATH (MONTHS)
15	Questionable infiltration left main bronchus Biopsy negative	Left pneumonectomy	No	Yes	2.75	6	Cells in sputum	Unknown
16	Lesion left main bronchus Biopsy positive	Left pneumonectomy	No	No	2.5	6	Cells in sputum and biopsy	12
17	Tumor level of middle lobe bronchus Biopsy positive	Right pneumonectomy	Yes	Yes	2.5	6	Biopsy	Unknown

*Operation considered palliative at conclusion of resection.

TABLE V. SUMMARY OF DATA FOR THE SINGLE CASE IN GROUP 5

CASE	PREOPERATIVE BRONCHOSCOPY	OPERATION	CONSIDERED PALLIATIVE?*	LYMPH-NODE INVOLVEMENT	MARGIN OF RESECTION	INTERVAL: RESECTION TO RECURRENCE (MONTHS)	RECURRENCE DIAGNOSED BY:	INTERVAL: RESECTION TO DEATH (MONTHS)
18	No lesion seen No biopsy	Right, middle, and lower lobectomy	No	No	No tumor in major bronchi	14	Bronchial smear	24

*Operation considered palliative at conclusion of resection.

scopic examination substantiated the diagnosis of vocal cord paralysis and recurrent carcinoma in the bronchial stump. Death occurred in this case 12 months postoperatively. Histologically, there was marked epithelial metaplasia in the proximal tumor-free resected bronchus in this and the other 2 cases in this group. The possible significance of this finding will be discussed in a later section.

Group 5.—In this category (Table V), there is 1 case which represents the only peripheral tumor which, to our knowledge, has recurred in the bronchial stump. The patient was the only woman in the series. Preoperative bronchoscopy failed to reveal any evidence of tumor but sputum contained malignant cells. Because the patient was 72 years old and there was no apparent lymphatic involvement, resection of the right middle and lower lobes was carried out. The tumor, 2.5 cm. in diameter, was located in the depths of the middle lobe. No involved lymph nodes were found, and serial sections of the proximal middle and lower lobe bronchi contained no evidence of tumor or epithelial metaplasia.

Hemoptysis developed 14 months postoperatively, at which time bronchoscopy revealed a firm, ragged lesion on the anteromedial wall of the right main bronchus about 2 cm. from the carina. Smears from this lesion contained malignant cells. Death occurred 2 years following pulmonary resection.

RÉSUMÉ OF FINDINGS AND COMMENT

There are no available reports concerning the recurrence of carcinoma in the bronchial stump. The true incidence of this entity is impossible to determine from a study of purely surgical material. Aufses states that he has definite evidence of stump recurrence in 6 cases of the 165 pulmonary resections for carcinoma performed between 1935 and 1948 at the Mount Sinai Hospital, New York. The present report is based on a study of 18 patients who developed recurrence in the bronchial stump after pulmonary resection for carcinoma at the Mayo Clinic. These cases were taken from a total of 631 patients who underwent resection for bronchogenic carcinoma prior to September, 1952.

All except 1 of the patients in this series were men, and the average age of the patients was 55.3 years. The average duration of symptoms prior to resection was 7.6 months.

Preoperative cytologic examination of sputum, bronchial washings, bronchial secretions, or more than one of these was carried out in 14 of the cases and gave positive results in 11.

Bronchoscopic examination was performed prior to thoracotomy in all 18 of these cases. In 11 cases a tumor was seen in either the right or the left main bronchus, and in 10 of 15 cases in which biopsy was performed the result was positive. In 3 cases some narrowing or infiltration was noted in or around the orifice of a secondary bronchus but biopsies were reported negative. In 4 cases the lesion was not visible bronchoscopically. The region of the carina appeared grossly normal in all 18 instances.

The findings at preoperative bronchoscopic examination are of special interest in view of the recent work of Rabin and his associates with biopsy near the carina. These workers stated that they have found the procedure extremely useful, since it produced positive findings in close to 20 per cent of patients who were considered otherwise operable. Apparently the result of biopsy may be positive even in the presence of grossly normal mucosa.

So-called carinal or paracarinal biopsies were not done in the cases in this series. Had this procedure been carried out, it is conceivable that results would have been positive in at least a few cases.

All the tumors which, in the Mayo Clinic series, have recurred in the bronchial stump were squamous-cell carcinomas of high histologic grade (Broders). The size varied from 1.5 cm. to 6.0 cm. in diameter. Lymph nodes in the hilus were involved in 12 cases.

In 16 cases a main bronchus was involved by the primary tumor at the time of pneumonectomy. These were equally divided between the right and left sides. The two tumors not originally involving a main bronchus were located in the right lower and in a peripheral right middle lobe bronchus, respectively. They were each treated by resection of the right middle and lower lobes with preservation of the upper lobe.

Symptoms of bronchial-stump recurrence appeared at intervals varying from 5 weeks to 24 months following resection. Attempts to explain many of these recurrences must, of necessity, be somewhat speculative. This is not true of the 5 cases in which gross or microscopic carcinoma was found at the line of bronchial resection. Obviously the "recurrence" was due to residual tumor in these cases. The situation, however, wherein resection of a relatively small, peripherally located carcinoma without demonstrable lymphatic spread is followed in 14 months by a bronchial-stump lesion identical histologically to the primary growth is more difficult to explain. It seems probable that by existing standards the initial resection was adequate. The possibility of an occult metastasis or seeding to the region of the main bronchus from the primary tumor at the time of operation must be considered. Similarly, a second primary carcinoma is a definite possibility. Spain and Parsonnet have reported the case of a 92-year-old woman whose bronchial tree showed multiple primary neoplastic changes. Williams has presented the case of a patient who had two separate invasive bronchogenic carcinomas.

The problem of in situ carcinoma is pertinent. Papanicolaou and Koprowska have reported a case of epidermoid carcinoma in situ of a right lower lobe bronchus. The tumor was detected by cytologic examination of sputum and its presence was proved at necropsy in one of a number of random blocks from the right lower bronchial tree. Umiker and Storey, Black and Ackerman, and Carlisle, McDonald, and Harrington have also demonstrated in situ changes in bronchial mucosa.

Minute parenchymal tumors believed to represent early bronchogenic carcinoma have been reported by Petersen, Hunter, and Sneeden. Aufses and Neuhof have reported 2 cases of very small bronchial cancer. Wierman has

recently presented a study of 5 cases of occult bronchogenic squamous-cell carcinoma. All these tumors involved major bronchi and were not readily apparent. One of the carcinomas was in situ and the other four were grossly minute, invasive lesions with in situ changes in the surrounding epithelium.

The question of what constitutes an adequate margin of bronchial resection is not easy to answer. The work of Griess, McDonald, and Clagett indicates that in squamous-cell bronchogenic cancers the minimal safe distance for excision of the bronchus is 1.5 cm. from the proximal limits of the tumor. By use of formalin-preserved surgical specimens, microscopic extension of some squamous-cell cancers was demonstrated in the submucosal bronchial layers for distances varying from 0.3 cm. to 1.5 cm.

Obviously a certain amount of shrinkage occurs in all tissues preserved in formalin solutions. It is not possible to state exactly how important this factor has been in the present study, but shrinkage of a semirigid, cartilage-supported bronchus is certainly much less than the high degree of shortening which takes place in the preservation of segments of alimentary tract and similar tissues.

It has been noted that epithelial metaplasia was present in the resected bronchi proximal to tumor in many cases in this series. The epithelial changes varied in degree from case to case and within the individual specimens. The earliest change noted was disorganization and palisading of cells in the basilar layers of otherwise normal bronchial mucous membrane. Other changes included pleomorphism, frank squamatization, and cellular mitoses. Several examples of epithelial metaplasia are illustrated in Figs. 1, 2*b*, and 4.

The difficulty in distinguishing between so-called metaplastic and neoplastic changes in tissues has been noted by several authors. Williams' case has already been mentioned. There were extensive intra-epithelial carcinomatous changes in the bronchial epithelium. Williams stated that the epithelial changes in this case might be considered by some pathologists to be so-called carcinoma in situ while others would regard them as cellular metaplasia. Spain and Parsonnet have also emphasized the difficulty in differentiating between cellular metaplasia and neoplastic changes.

Carlisle, McDonald, and Harrington, in a study of bronchogenic squamous-cell carcinomas at the Mayo Clinic, noted that a small zone of mucous membrane adjacent to many of these tumors contained in situ changes. Similarly, Womack and Graham have noted a case of bronchogenic carcinoma in which the mucosal epithelium adjacent to the tumor showed patchy metaplasia with considerable mitotic activity. They considered this metaplasia to be a precancerous condition. Reingold and associates, in a necropsy study of 60 cases in which the patients had died of bronchogenic carcinoma, reported several instances in which the gradation from normal bronchial mucosa through squamous metaplasia to epidermoid carcinoma was observed.

According to Willis, Karl Tiersch, in 1865, suggested that the recurrence of an epithelial tumor following surgical excision was not always due to

incomplete removal of tumor tissue, but was sometimes due to new carcinomatous change in the predisposed epithelium of the region.

It is rather disturbing that the interval from pneumonectomy to recurrence was nearly the same in cases with carcinoma present at the line of bronchial resection as in some cases with only metaplastic epithelium in the proximal excised bronchus. It is possible that the latter, morphologically still benign epithelium, may in reality be carcinoma. Perhaps the same amount of time is necessary for residual carcinoma in the bronchial stump to reassert itself as is required for metaplastic epithelium in the carinal region to bleed and initiate coughing. Further study of this problem seems necessary. It may be that in a case of bronchogenic squamous-cell carcinoma the finding of metaplastic epithelium near the carina is of nearly as much prognostic significance as is the presence of frank carcinoma in this region.

Blood-vessel involvement was demonstrated in a bronchus in only 1 case in this series. In this case, blood vessels in the bronchial wall were involved at a point 1.0 cm. from the proximal resected end of the main bronchus. This finding could certainly account for the bronchial-stump recurrence. It is of interest, though, that Ballantyne found blood-vessel involvement in 80 per cent of bronchogenic squamous-cell carcinomas. He noted, however, that blood vessels were involved in 16 of 27 patients who survived 2 to 5 years after pulmonary resection for squamous-cell cancer and concluded that the presence of malignant cells in a blood vessel does not make metastasis a certainty.

As might be expected, the commonest symptom of bronchial-stump recurrence was cough, which occurred in some degree in all cases. This was usually productive and in 16 cases hemoptysis appeared. Hoarseness due to paralysis of the left vocal cord occurred in 4 cases. Cough and hemoptysis following pulmonary resection for carcinoma may be due to benign granulation tissue. Persistence of these symptoms must be viewed with suspicion, however, and bronchial-stump recurrence should be considered.

Bronchial-stump recurrence appears to be of serious prognostic significance. Of 13 cases in which data are available, only 4 patients survived 2 years or more following resection despite treatment in several instances with deep x-rays or locally implanted radon seeds or both.

SUMMARY AND CONCLUSIONS

1. A clinicopathologic study has been presented of 18 patients in whom bronchial-stump recurrence developed following pulmonary resection for a squamous-cell carcinoma of the lung.

2. In 16 cases a main bronchus was involved by the primary tumor. Eight of these were on the right and the same number were located in the left lung. In 12 cases, lymph nodes in the pulmonary hilus were metastatically involved.

3. In 11 cases, the tumor was visualized bronchoscopically prior to resection. The region of the carina was not grossly involved in these patients preoperatively. On the basis of the present study, however, it is believed that bronchoscopic biopsy near the carina might have been helpful in assessing operability in several instances.

4. In 5 of the 18 cases in this series, pathologic examination of the surgical specimens revealed the presence of carcinoma at the proximal end of the resected bronchus. In 9 cases the margin of resection beyond the tumor was less than 1.5 cm., and the bronchial mucosa proximal to tumor was metaplastic in 7 of these. In 3 of the 18 cases, the bronchus was resected at least 2.5 cm. beyond the tumor. The proximal bronchial epithelium was metaplastic in all 3, however. The tumor in 1 case involved no major bronchi and the bronchial epithelium showed no evidence of metaplasia.

5. Metaplasia of the bronchial epithelium was a common finding in this study, and its possible importance in the etiology of certain bronchial-stump recurrences has been discussed.

6. In this study the interval from pulmonary resection to the appearance of symptoms of bronchial-stump involvement varied from a few weeks to almost 2 years.

7. The most constant symptom of bronchial-stump recurrence was cough, which occurred in some degree in all cases. Hemoptysis appeared in all but 2 cases. In 4 cases hoarseness developed as a result of vocal-cord paralysis. The occurrence and persistence of cough and hemoptysis after resection for bronchogenic carcinoma must be considered a recurrence in the bronchial stump until proved otherwise.

8. The diagnosis of bronchial-stump recurrence was established by bronchoscopy in 16 cases and by cytologic examination of sputum in the remaining 2 cases in this series.

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ABDOMINAL PAIN FOLLOWING SURGICAL CORRECTION OF COARCTATION OF THE AORTA: A SYNDROME

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OUR attention was recently focused on singular events in the postoperative course of 2 patients on the cardiovascular service of this hospital. These men had had surgical excision and repair of typical thoracic aortic coarctations performed within a few days of each other. Thereafter, both, in the early postoperative period, developed profound abdominal pain and tenderness with marked leukocytosis and fever for which we had no ready explanation. Within ten days these findings subsided with conservative therapy. Our associates volunteered similar experiences and this induced us to review the postoperative course of patients treated here for this anomaly.

Sealy,[1] in 1953, reported a case of abdominal distress with development of intestinal infarction following repair of aortic coarctation and Lober and Lillehei[2], from this Clinic, wrote of two instances of necrotizing panarteritis of the abdominal viscera following resection of coarctation. Perez-Alvarez and Oudkerk[3] also reported an instance of similar nature.

Since 1950, the diagnosis of coarctation has been coded in this hospital 88 times. Seventy-three of these patients came to surgery and of this group 64 survived at least the early postoperative period. Eighteen patients in this group had significant abdominal findings and symptoms in the early postoperative period. We have arbitrarily divided these 18 patients into three groups on the basis of intensity of signs and symptoms.

The first group, which showed the mildest symptoms, consisted of 10 patients (one female) ranging in age from 2½ to 34 years (average 23 years). All of these complained of generalized abdominal pain during the first to third postoperative days. One or more of the following problems was present in each instance: abdominal distention, gastric dilatation, abdominal tenderness, ileus, or vomiting. Leukocytosis was present (13,000 to 20,000) with mild temperature elevation (101° F.). These complications responded to restriction of oral intake, gastric suction, and intravenous administration of fluids. Since such problems may arise following thoracotomy, for whatever reason, we cite this group only to point out the incidence of abdominal distress following resection of coarctation. The following case is an example from this group:

D. J. (UH #857949).—The patient was a 28-year-old white man with a history of "dizzy spells" for several years and dyspnea on exertion of six weeks' duration. Physical

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findings revealed a 144 pound individual with a right brachial artery pressure of 150/90 and left pressure of 150/88. There was a loud precordial systolic murmur that radiated to the back. Femoral pulses were not palpable.

X-ray showed slight left ventricular enlargement and the electrocardiogram indicated left axis deviation.

Resection of the coarctation was done on May 21, 1953. The proximal aorta was 3 cm. in diameter with a 4 mm. opening in the coarctate segment. The ductus arteriosus was not patent.

On the third postoperative day, the patient developed generalized abdominal pain, distention, and diarrhea. The WBC was 17,100, and the temperature was 101° F. The patient required 50 to 75 mg. of Demerol for six days. The symptoms relented after three days of gastric suction and intravenous fluids.

The blood pressure on the third postoperative day was 140/90. The femoral pulses were of good quality. At six-month check, the blood pressure was 126/86.

A second group of 4 patients (all male) experienced similar difficulties but of more serious nature. The ages ranged from 4 to 36 years (average 19.5), the onset of symptoms was in the first postoperative week and persisted for seven to ten days. Here again abdominal distress was significant and x-ray examination showed that ileus was largely confined to the small bowel. Severe generalized abdominal pain and tenderness with rebound were manifest. Vomiting occurred on several occasions. Pyrexia (103° F.) and leukocytosis (15,000 to 30,000) were consistently present without obvious explanation.

These patients were studied during and subsequent to the acute episode from which they all recovered by conservative means of treatment. The only abnormal laboratory finding was the elevation of the white blood count. Serum amylase studies were normal. Muscle biopsy of the lower extremity in one instance was not revealing. X-ray studies of the intestinal tract during subsidence of the acute episode presented no abnormality in one instance. The following case history is an example from this group:

R. V. (UH #878584).—The patient was a 22-year-old man who gave a vague history of dizzy spells. His weight was 159 pounds and blood pressure on admission measured 210/108. A systolic precordial murmur was heard. The femoral pulses could not be felt.

X-ray showed left ventricular enlargement and the electrocardiogram demonstrated left ventricular hypertrophy.

Surgical correction of the coarctation was performed on Jan. 6, 1955. Arterial collateral channels were extremely rich in the chest wall. The aorta measured 1 cm. in diameter with a 1 mm. opening in the coarctate segment.

On the tenth postoperative day, the patient developed severe abdominal pain with distention and vomiting. The temperature was 101° F. The WBC was 29,000 with 88 per cent polymorphonuclear neutrophil leukocytes. The patient described a "pumping" pain in the legs. With gastric suction and intravenous fluids, the patient slowly improved. He required 5 to 10 mg. of methadon for pain for ten days after this acute episode for which no explanation could be found. The blood pressure in the right arm measured 130/80 at the time of its onset. Since discharge from the hospital the patient has done well.

The third group of 4 patients (4 males, aged 3 to 46 years) were subjected to laparotomy within two weeks following correction of the coarctation. The diagnosis of appendicitis was entertained in 3 of these patients. The striking feature of this group is the similarity of abdominal findings. Poorly localized abdominal pain and tenderness, beginning on the seventh to tenth postoperative

day with leukocytosis and fever, were associated with nausea and vomiting with rebound tenderness. This led to the diagnosis of a "surgical abdomen," but in no instance was a specific diagnosis made preoperatively.

Two of these cases were previously reported by Lober and Lillehei.[2] Here, necrotizing panarteritis indistinguishable from periarteritis nodosa was found with infarction of portions of the small intestine. One patient succumbed from a ruptured splenic aneurysm. The second, subjected to a bowel resection by one of us (F. J. L.), recovered. A third patient had a negative laparotomy but expired one month later from a ruptured dissecting aneurysm of the thoracic aorta. The fourth patient in the group had only enlarged mesenteric lymph nodes found at surgery and he subsequently recovered. The following 2 cases are examples from this group:

J. S. (UH #850534).—The patient was a 3-year-old boy who was admitted to the hospital with a history of episodes of cyanosis and shortness of breath on exertion and congestive heart failure.

Physical examination revealed a blood pressure of 134/60 right arm and 130/60 left arm. A precordial systolic murmur was heard which radiated to the back. The femoral pulses were absent.

X-ray showed right and left ventricular enlargement and the electrocardiogram showed right axis deviation.

Surgery was performed on March 3, 1953, and minimal arterial collaterals were encountered in the chest wall. The ductus arteriosus was closed. The aorta measured 1 cm. in diameter and the coarctate segment was 2 mm. in diameter. Arteriosclerotic changes were noted on microscopic section of the aorta immediately adjacent to the constricted area.

On the seventh postoperative day the child developed abdominal pain, rigidity, and generalized tenderness. The WBC was 16,200. The rectal temperature was 101° F. Two days later the symptoms seemed progressive and laparotomy was done with findings of mesenteric adenitis. The patient recovered uneventfully and was discharged on the eighteenth day following the original surgery.

E. H. (Associated Hospital).—This 46-year-old white man had been treated for pulmonary tuberculosis in February, 1953, by right upper lobectomy. He had no symptoms directly related to the coarctation.

Physical examination showed blood pressure in the upper extremities of 200/100 with absent femoral pulses. An apical systolic murmur was heard.

X-ray examination showed left ventricular enlargement.

Corrective surgery was done on May 6, 1953. A typical coarctation was resected with end-to-end anastomosis.

On the eighth day after surgery, the patient developed fever and vomiting. Two days later the abdomen was distended, tender, and rigid. The temperature at this time was 103° F. Abdominal exploration was carried out, and free pus was found in the peritoneal cavity. Gangrenous patches were present along the ileum and distal part of the jejunum. Thirty-eight centimeters of the small intestine were resected. The mesenteric vessels were not grossly abnormal. The postoperative course was not remarkable.

The pathologic changes of medial necrosis with cellular infiltration and fibrinoid deposits, similar to periarteritis nodosa, have been described elsewhere.[2]

Table I sets forth the general data regarding this group of patients with coarctation of the aorta. In this series of patients receiving surgery, 9 expired on the table and this number, in conjunction with those who did not receive surgery, left a total of 64 patients who survived sufficiently long into the postoperative period to be evaluated. The 18 cases with significant abdominal findings constitute 28 per cent of this group. The total number of women in the surgical group was 25 (28.2 per cent).

TABLE I. COARCTATION OF THE AORTA
(73 PATIENTS OPERATED UPON)

	AGE (YEARS)				
	<1	1-5	6-25	>25	TOTAL
Number of Patients	15	8	38	12	73
Deaths	8	0	3	2	13
Abdominal Findings.—					
Moderate I	0	2	4	4	10
Severe II	0	1	2	1	4
Surgical III	0	1	2	1	4

An analysis of the 18 patients under consideration reveals some interesting points. The average age of Group I was 23 years, Group 2 was 19.5 years, and Group 3 was 19 years, while the average over-all age was 11 years. There was one woman (5 per cent) in the group of 18 patients with abdominal symptoms, compared to the over-all figure of 28.2 per cent. The other 2 cases reported in the literature were also men. An effort was made to correlate the pre- and postoperative (seventh to tenth day) blood pressures of the group of 18 with those of the whole group of surgical patients and generally the patients developing abdominal complications seemed to have an earlier and more marked drop in pressure, especially those in the older age group (Table II). No consistent trend could be detected in comparison with preoperative palpability of femoral pulse or estimated degree of chest wall collaterals at the time of surgery.

Pentothal sodium anesthesia was routinely employed. The postoperative care of all surgical cases was essentially the same. Penicillin and streptomycin were employed for five to seven days and in only one instance was there overt evidence of sensitivity reaction to these agents.

DISCUSSION

Since necrotizing arteritis was found in tissue removed at surgery from 2 of our patients (previously reported), and in the case cited by Perez-Alvarez,[3] the possible relationship of this process to periarteritis nodosa has been considered. Inasmuch as the value of study of the rare entity frequently lies in the elucidation of the common entity, this pursuit seems to have merit.

Since the original description in 1866 by Kussmaul and Maier, periarteritis has been alternately considered a distinctly separate disease and a general term for a group of disorders based pathologically on necrotizing inflammation of muscular arteries. Zeek and others[4, 5] have helped to resolve this problem by listing periarteritis nodosa as one distinct form of necrotizing angitis characterized histologically by inflammation and fibrinoid necrosis of the muscular arteries. That hypersensitivity reactions are its sole etiology seem no longer tenable. A hypertensive factor in the etiology of periarteritis nodosa seems quite appealing in view of the laboratory demonstrations by Kempner and co-workers,[6] of the development of this disorder in rats, secondary to elevations of arterial pressure. The liver arterialization studies of Rather and Cohn[7] in producing necrotizing lesions in the hepatic vascular tree and the evidence that increased intravascular tension is directly concerned in the production of acute arterial necrosis (Byrom and Dodson[8]) add weight to the thesis that intravascular trauma may produce definite acute pathologic changes in the arterial wall.

TABLE II. AVERAGE BRACHIAL ARTERIAL BLOOD PRESSURES
(BEFORE AND AFTER CORRECTION OF COARCTATION)

	ENTIRE SURGICAL GROUP								PATIENTS WITH ABDOMINAL FINDINGS					
	<1		1-5		5-25		>25		1-5		5-25		>25	
AGE (YEARS)	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER
	128/96	109/50	154/68	126/x	155/96	139/82	176/113	164/108	133/70	120/60	178/101	141/85	196/100	146/90
Systolic drop		19		28		14		12		13		37		50
Diastolic drop		46		x		14		5		10		16		10

The confinement of periarteritis lesions to the vessels subject to systemic blood pressure and the freedom of the pulmonary system (except in instances of pulmonary hypertension) from vascular necrosis suggests that some limited factor is at play in this disease.

The one common factor in all cases studied was the sudden increase in pulsatile pressures in the arterial system distal to the coarctation. The signs and symptoms in our cases were confined to the visceral areas subject to this increased pressure head. This appeared especially true of the structures supplied by the superior mesenteric artery.

The abdominal pain manifest in all of our patients may be related to the arterial distention stimulating viscerosensory fibers in the vessel wall. It is noted that one of the patients complained of epigastric pain, "pumping" with each heartbeat. The prolonged requirement for narcotics (five to ten days) in our series of postoperative cases was consistently noted.

That the majority of the postoperative patients with coarctation can tolerate this change must represent an adaptation less well handled by the 18 cases in point. It would seem that the patients demonstrating significant abdominal findings represent a varying pathologic response to the elevated arterial pressures in the postcoarctation vasculature ranging from temporary functional disturbance to local lysis of overstretched medial muscular fibers, vascular occlusion, and tissue death. The two instances in this series of pathologic changes identical to periarteritis nodosa were limited to vessels beyond the coarctate area and represent an extreme expression of the devastating influence of acute overdistention of the arterial tree.*

We have no ready explanation for the preponderance of males in this group showing abdominal distress after corrective surgery. The tendency for the older patient to develop the syndrome may in part be due to the inability of the older vessels to adapt to the elevated pressures. That the age of the vessel is not gauged wholly by the chronological age of the patient is indicated by 2 cases of youthful patients in the group of 18 (ages, 2½ and 5) in which arteriosclerotic stages were noted in the aorta proximal to the coarctation.

SUMMARY

A series of 18 cases presenting similar signs and symptoms of varying intensity referable to the abdomen, following repair of coarctation of the aorta, is reported. Possible etiological factors are discussed. We feel that this entity justifies the term "syndrome." Cardiovascular surgeons should be alert for this complication. Certainly this problem deserves further study.

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CHONDROSARCOMAS OF THE THORACIC SPINE

Report of Two Cases

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As the scope of thoracic surgery has increased in recent years, it has not only enabled more accurate diagnosis but also has stimulated greater interest in lesions which were formerly relegated to the field of academic interest only. Chondrosarcoma of the thoracic spine falls in this category.

Presented herewith are 2 case reports of thoracic vertebral chondrosarcomas which present rather unique features both clinically and pathologically.

The rarity of chondromatous tumors of the thoracic spine is attested by the sparse literature on the subject. Geschickter and Copeland[1] in reporting 321 instances of osteochondromas from the Johns Hopkins Hospital up to 1949 found only one lesion of the thoracic spine. Weisel, and Ross[2] reported a chondrosarcoma in 1950 and Ilgenfritz[3] reported a most unusual osteochondroma of the upper spine in 1951. We have been unable to find previous reference or record of resection of chondrosarcomas of the thoracic spine.

CASE REPORTS

Case 1.—A white man, aged 32 years, was referred for thoracotomy because of a homogeneous ovoid opacity in the posterior mediastinum adjacent to the right lung field and at the level of the sixth thoracic vertebra. This had been asymptomatic and was first discovered on a routine Army chest x-ray examination. The lesion measured about 5 cm. in maximum diameter. Past history was noncontributory. Bronchoscopy was unremarkable.

Exploratory thoracotomy demonstrated a smooth-walled mass about 8.0 by 6.0 cm. in diameter which was brittle to touch. It was attached to the body of the sixth thoracic vertebra. The mass was excised, and the vertebral body curetted.

Grossly, the lesion was a mass of hemorrhagic and soft, translucent, mucoid material with calcific particles scattered throughout. Histologic sections (Figs. 1 and 2) demonstrated hyaline cartilage, bone, and myxomatous tissue. The diagnosis of chondrosarcoma was arrived at mainly because of plumpness and hyperchromatism of the chondrocytic nuclei. The myxomatous portions exhibited nuclear hyperchromatism and irregularity in addition to necrosis with hemorrhage. These were presumed to represent degenerative changes.

The patient made an excellent recovery. A two-year follow-up finds him well and active with no recurrence.

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Fig. 1.—Case 1. Histologic section.

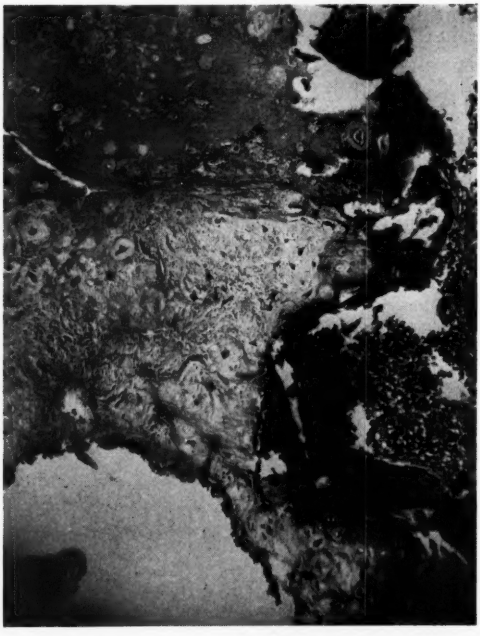

Fig. 2.—Case 1. Histologic section.

CASE 2.—A white woman, aged 20 years, had been in good health until she was hospitalized for right lateral thoracic pain of pleuritic character. Chest x-rays disclosed a right pleural effusion (Fig. 3). Thoracentesis demonstrated bloody serous fluid. Cytologic studies of this were negative. Postthoracentesis x-rays (Fig. 4) showed a partly calcified rounded opacity of the posterior mediastinum arising at the level of the seventh thoracic vertebra and extending into the right lung field. This measured about 10.0 cm. in maximum diameter.

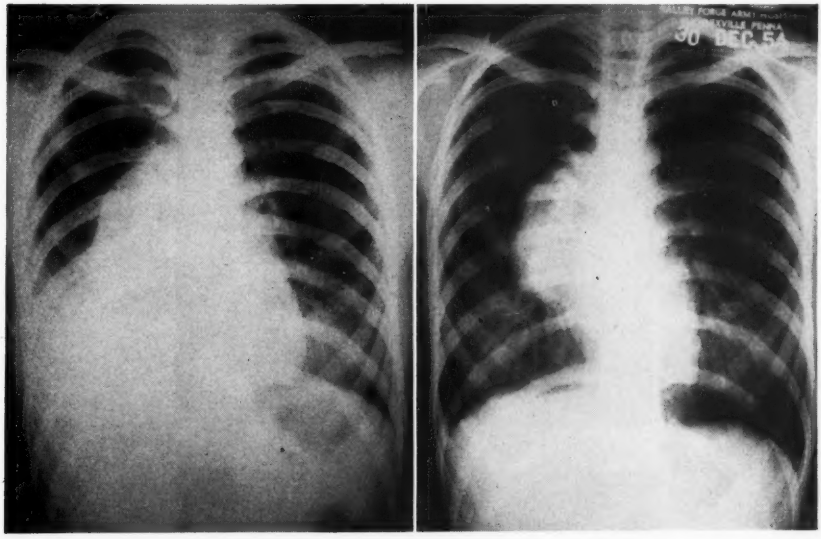

Fig. 3. Fig. 4.

Fig. 3.—Case 2. Before aspiration of hemothorax.
Fig. 4.—Case 2. After aspiration of hemothorax.

Exploratory thoracotomy presented an ovoid mass, the upper two thirds of which was covered by a smooth surface, presumably parietal pleura. The lower portion was fragmented, hemorrhagic, and focally myxomatous. A fresh clot of blood extended downward from the lesion. The mass was rather tenuously attached to the body of the seventh thoracic vertebra. The lesion was removed, and the area of attachment curetted. A near-by mediastinal lymph node measuring 2.0 cm. in maximum diameter was removed separately. Histologic sections demonstrated a lesion essentially similar to that of Case 1 (Fig. 5). A particularly interesting finding was the presence of neoplastic tissue in a lymphatic vessel adjacent to the lymph node (Fig. 6).

The patient recovered uneventfully from surgery (Fig. 7). She is now well with no evidence of recurrence six months following surgery.

COMMENT

Our experience with these 2 patients has called to our attention an entity which is not considered often in the diagnosis of posterior mediastinal lesions. The radiologic findings were sufficiently distinctive as to suggest at least a correct diagnosis of chondrosarcoma in these cases. In our second patient, the appropriate diagnosis was considered prior to thoracotomy although neurofibroma was somewhat more strongly suspected.

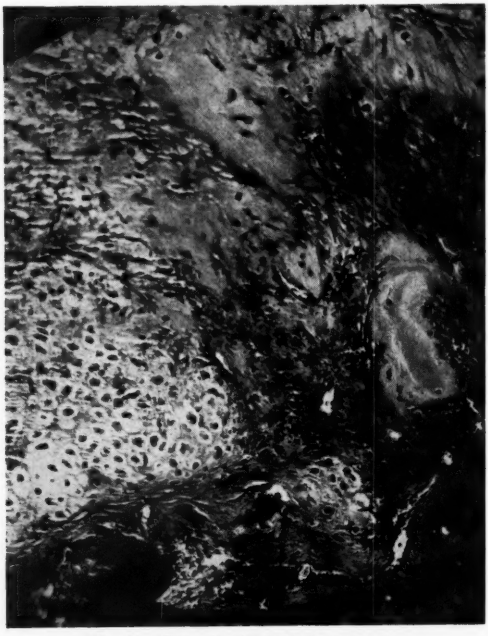

Fig. 5.—Case 2. Histologic section.

Fig. 6.—Case 2. Histologic section.

The gross findings in each of these patients were unique in our experience, namely, the presence of a brittle mass composed largely of soft, gray, translucent mucoid material. In retrospect, these gross findings at surgery should have suggested the diagnosis of myxoma or chondrosarcoma in each instance.

Since chondrosarcomas are a rarity and since myxomatous changes are characteristic of chondrosarcoma, this point is considered worthy of emphasis. This is particularly important since such tissue does not lend itself to frozen section diagnosis.

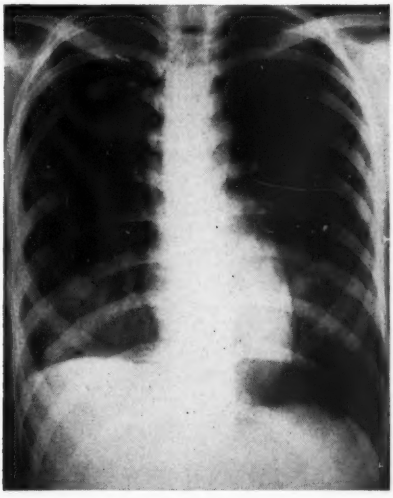

Fig. 7.—Case 2. Postoperative x-ray.

A particularly interesting finding in the second case was the lymph node metastasis. Lymphogenous metastases are rarely reported secondary to chondrosarcoma. The metastatic involvement in this case offers corroborative biologic evidence of the malignant nature of the lesion. This is important inasmuch as the histologic criteria of malignancy in the cases we are reporting, as well as in many of the cases of chondrosarcoma reported elsewhere, are of rather equivocal character. Mitoses are rarely seen in any significant number in chondrosarcomas inasmuch as growth of cartilage is by amitotic division. We saw no mitoses in the tissue from our cases. On the other hand, the criteria of malignancy as set forth by Lichtenstein and Jaffe[4] were satisfied. These include plumpness of nuclei, more than occasional cells with double plump nuclei and giant cartilage cells.

It is not possible to indicate with certainty the histogenesis of the lesions in these 2 cases. Various authors have suggested that chondrosarcomas arise either from cartilagenous rests or from osteochondromas. O'Neal and Ackerman[5] have mentioned that it is frequently difficult to determine the manner of origin of malignancies of cartilagenous nature. Although both bone and well-differentiated cartilage were found in each of these lesions, it was not oriented

in such a manner as to suggest origin from osteochondromas. In other words, it was not possible to delineate well-differentiated bone overlaid by a cartilaginous "cap." It would seem worth while to attempt to prove such a relationship since this would provide additional information relative to the proper handling of osteochondromas, although most authors agree that the incidence of malignancy in osteochondromas is very low.

It seems worth mentioning that the location of these lesions adds some support to the concept of Roberg[6] that cartilaginous neoplasms situated near the body axis are more apt to be malignant.

SUMMARY

Two unusual cases presenting chondrosarcomas of the thoracic vertebrae are reported. Diagnostic and pathologic implications have been discussed.

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CONGENITAL EVENTRATION OF THE DIAPHRAGM

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CONGENITAL eventration of the diaphragm is an unusual condition. The normal diaphragmatic muscle is replaced by a thin, translucent, fibrous membrane. Usually only the central dome is affected, causing the diaphragm to balloon high up into the pleural cavity. Rarely is the entire diaphragm involved.

Although over 300 cases[1] have been reported in the literature, successful surgical repair in infancy is rare. Arnheim[2] in a review of the literature, in 1954, collected a series of 8 cases. In 1954, Laxdal and associates[1] reported an additional 2 cases. One infant, aged 7 weeks, was operated upon successfully; the other patient, aged 28 days, died without surgery.

In 1952, Ravitch and Handlesman[3] reported surgical repair of small defects in the right diaphragm in a series of 5 infants. These were small areas of eventration with herniation of the liver. These cases cannot be classified as true eventration of the diaphragm.

In 1947, Bisgard[4] performed the first successful surgical repair of eventration of the diaphragm in infancy.

The case reported here is the tenth infant to undergo successful surgical repair, and the fourth case with involvement of the right diaphragm.

A different surgical technique is demonstrated which preserves the normal function of the diaphragm.

CASE REPORT

T. S., a white male infant, was delivered normally at St. Francis Hospital on April 12, 1953. The birth weight was 8 pounds, 5 ounces. He was re-admitted to the hospital on May 14, 1953, on the service of Dr. Edward Giunta.

The mother stated that the baby had a chronic "brassy" cough, noted one week after birth. The baby did not take his feedings well and had failed to gain weight. He had occasional periods of dyspnea and slight cyanosis, especially during feedings.

Physical examination revealed a moderately undernourished 4-week-old infant, weighing 8 pounds, 7 ounces. There was slight cyanosis of the lips. On inspiration, there was reduced expansion of the right hemithorax. Breath sounds were decreased on auscultation over the right base of the chest.

Roentgenologic examination of the chest revealed an abnormally high position of the right diaphragm. The dome of the diaphragm extended to the third anterior intercostal space (Fig. 1). Fluoroscopy of the chest revealed decreased excursion of the right diaphragm. Roentgenologic examination of the esophagus and stomach revealed normal position and contour of the esophagus. The fundus of the stomach was in normal position,

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but the pylorus and first part of the duodenum were high and to the right of the midline. The stomach was slow to empty. The remaining laboratory work was within normal limits.

Because of the severity of the symptoms, and failure to gain weight, surgical correction of the diaphragmatic eventration was decided upon.

Operative Procedure.—The baby was operated upon by one of us (R. A. D.) on May 25, 1953. Endotracheal anesthesia, using cyclopropane, was administered by Dr. W. O. McQuiston. A cut-down was performed on an ankle vein for administration of fluid and blood.

The chest was opened through the right eighth interspace. The dome of the diaphragm was found to consist of a thin, translucent, fibrous membrane, and extended nearly to the apex of the pleural cavity. It was much higher than appeared on the chest roentgenogram. The liver could be seen underneath the thin membrane. The right lower lobe showed small areas of atelectasis, due to external compression. The periphery of the diaphragm was found to consist of fairly normal muscular tissue.

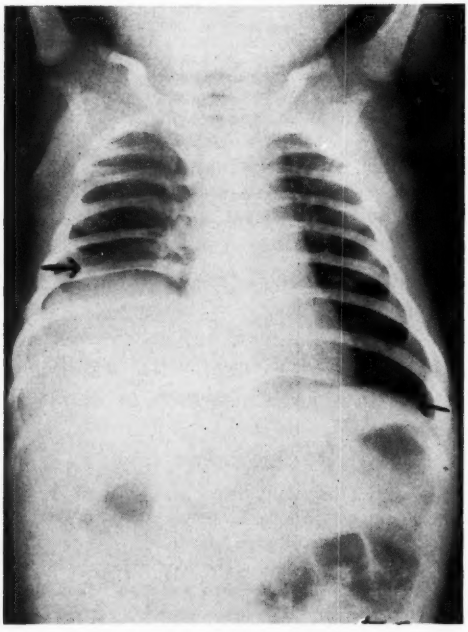

Fig. 1.—Preoperative roentgenogram showing elevation of right diaphragm.

The entire diaphragm was incised in the midline, extending from the lateral chest wall to the mediastinum (Fig. 4). This divided the diaphragm into anterior and posterior halves. The excess thin membrane was then excised, and the two halves of the diaphragm were imbricated with interrupted mattress sutures of No. 2-0 black silk. This brought the diaphragm down to a normal position. The functioning diaphragm now consisted of muscular tissue. At the conclusion of the operation, rhythmical respiratory contraction of the diaphragm was noted, indicating a functioning phrenic nerve. A small Pezzer catheter was inserted through the seventh interspace for drainage and connected to a water-seal bottle. The chest was closed with two pericostal sutures of No. 2-0 chromic catgut around the eighth and ninth ribs.

The muscles of the chest wall were approximated with continuous No. 3-0 chromic catgut, and the skin with continuous No. 4-0 silk. The baby received 75 c.c. of blood during surgery and left the operating room in good condition. The total operating time was one hour and twenty minutes. The infant was placed in an oxygenated crib for twenty-four hours. The chest drainage catheter was removed in forty-eight hours. The infant tolerated oral feedings on the second postoperative day. The skin sutures were removed on the seventh day. A chest

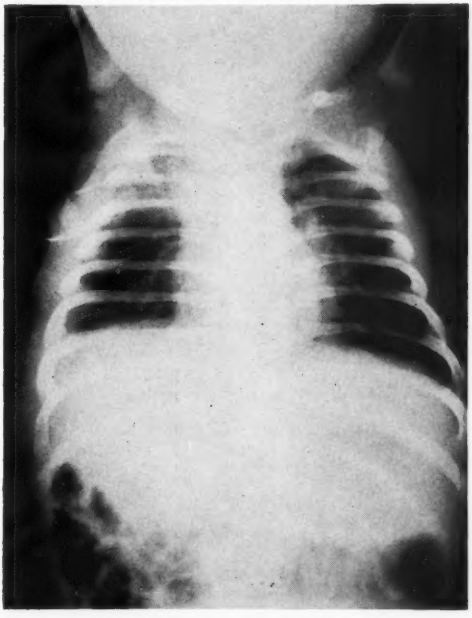

Fig. 2.—Roentgenogram taken one week postoperatively showing normal position of right diaphragm.

Fig. 3.—Photograph of infant at the age of six weeks showing operative approach.

roentgenogram taken one week postoperatively shows normal position of the right diaphragm (Fig. 2). The patient was discharged from the hospital on May 31, 1953, weighing 9 pounds, 9 ounces (Fig. 3).

The infant had complete relief of symptoms following surgery. The family moved to Denver, Colorado, a few months after the operation.

Recent communication with the child's mother indicates that he has developed normally and is free from all symptoms. A chest roentgenogram taken at the age of 2 years by the family physician, Dr. M. E. Smernoff of Denver, Colorado, was forwarded to us. This shows maintenance of normal position of the right diaphragm (Fig. 5). The child has had normal physical development during those two years.

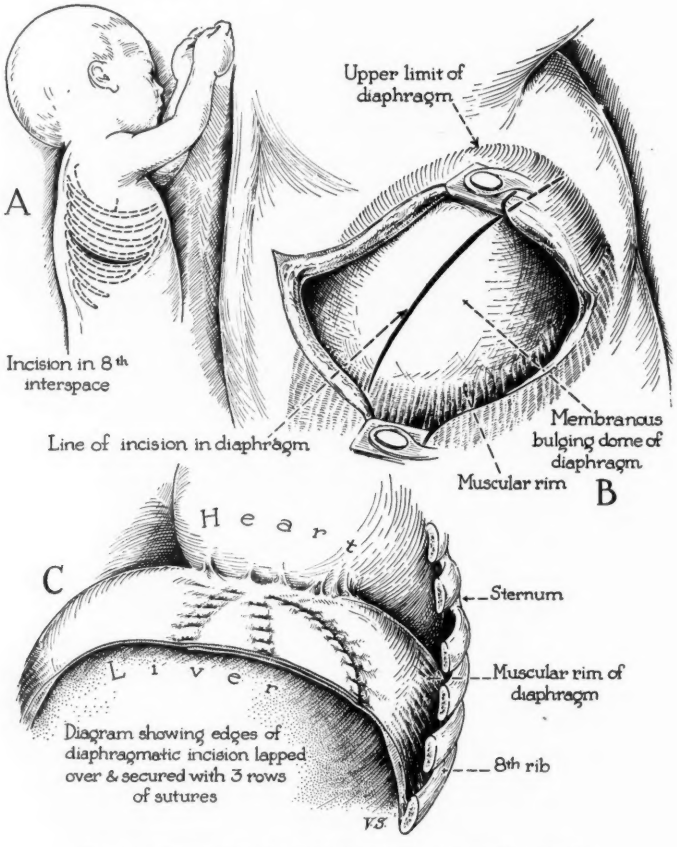

Fig. 4.—Illustration showing technique of surgical repair.

DISCUSSION

The etiology of this defect appears to be a congenital malformation of the diaphragmatic muscle. All of the diaphragm may be involved, but usually it is the central dome.

The intra-abdominal pressure forces the thin membranous diaphragm upward, compressing the overlying lung. There may be a shift of the heart and mediastinum to the opposite side. The above factors may easily produce dyspnea and cyanosis in the young infant.

Eventration of either side may cause angulation of the stomach and pylorus, with partial pyloric obstruction and vomiting. In our case, the pylorus was elevated upward, causing gastric retention and difficulty with feedings.

The diagnosis is usually made by roentgenograms and fluoroscopy. The diaphragm is seen as a thin, curved line, extending high in the pleural cavity. Fluoroscopy reveals slight or no motion on respiration.

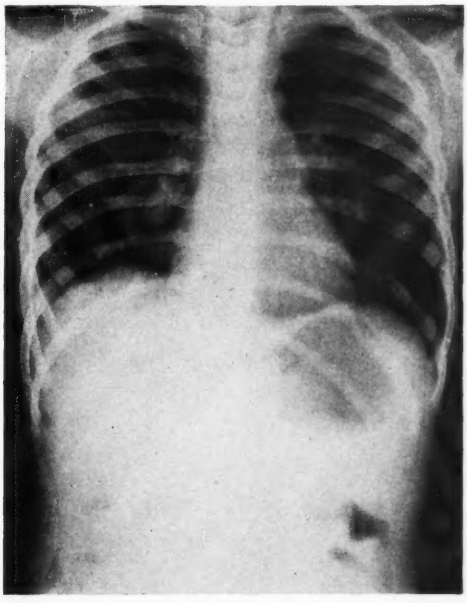

Fig. 5.—Roentgenogram taken at the age of two years showing maintenance of position of right diaphragm.

This condition is to be differentiated from diaphragmatic hernia and from phrenic paralysis. If required, barium studies of the gastrointestinal tract should establish the diagnosis of diaphragmatic hernia. It is said that paradoxical motion of the diaphragm can be observed with phrenic paralysis. Quite often there is also brachial plexus paralysis if the trauma is due to childbirth.

Pneumoperitoneum has been used frequently to aid in differential diagnosis in adults; it could also be used in infants if necessary.

Treatment depends on severity of the symptoms. Surgery does not seem necessary for small defects with no symptoms. However, if the eventration is large, with symptoms of dyspnea, cyanosis, cough, and vomiting, immediate surgical repair is indicated. To date, no operative deaths have been reported and the long-term results have been excellent.

Various operative techniques have been described, using both the abdominal and thoracic approach. The usual procedure has been to plicate the

thin membranous portion in toward the liver. This portion can then be anchored to the chest wall. Tantalum mesh may be used, as reported by Sanford.[5] In our case, it was decided to excise the membranous portion and to imbricate the two portions of the muscular rim. This procedure gave a strong diaphragmatic repair and did not restrict the motion of the diaphragm.

SUMMARY

1. A case of eventration of the right diaphragm in a six-week-old infant is reported.

2. Successful surgical repair was performed by imbricating the muscular rim of the diaphragm.

3. Symptoms of dyspnea, cyanosis, and cough were completely relieved.

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PREVENTION OF FOAMING IN SUCTION BOTTLES FOLLOWING PULMONARY RESECTION

GEORGE L. NARDI, LIEUTENANT COMMANDER (MC) USNR*

THE combination of blood and air bubbling through a water-seal trap after pulmonary resection frequently creates abundant and bothersome frothing. This froth is a nuisance to those engaged in the postoperative care of the patient since bubbles rapidly fill the first drainage bottle and siphon over to the second and third bottles. As a result, the entire suction unit becomes a collection of bloody foam which makes accurate estimation of drainage volume difficult, requires frequent changes of bottles, and is a mechanical hazard to the suction pump.

The addition of a few drops of caprylic alcohol (octyl alcohol, normal-primary) to the first bottle completely prevents any foaming and simplifies this phase of postoperative care.

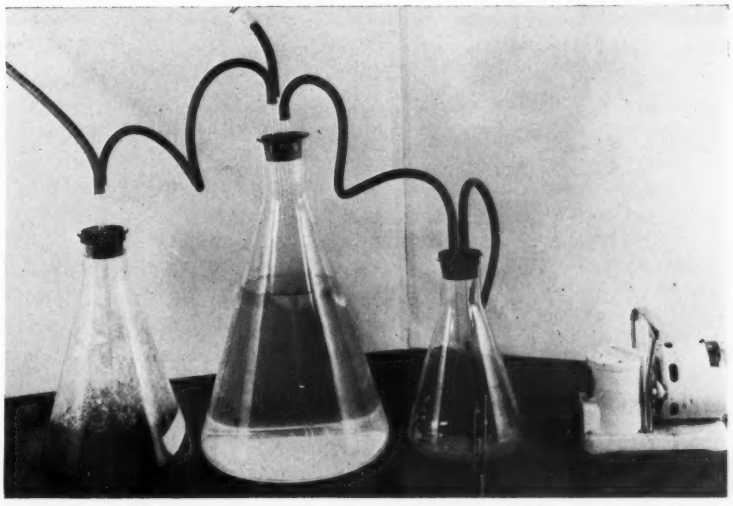

Fig. 1.—A typical 3-bottle chest suction unit with foaming beginning in the first bottle.

From U. S. Naval Hospital, Portsmouth, Va.

The opinions or assertions contained herein are those of the authors and are not to be construed as official or reflecting the views of the Navy Department or of the Naval Service at large.

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Caprylic alcohol is a colorless liquid with a pleasant, penetrating, aromatic odor. It is insoluble in water. Its specific gravity is 0.827.[1] Accordingly, the small amount used is highly dispersed, remains on the surface, and will not have access to the submerged portion of the drainage tube communicating with the patient's chest. Hence, any hazard of retrograde aspiration is minimized.

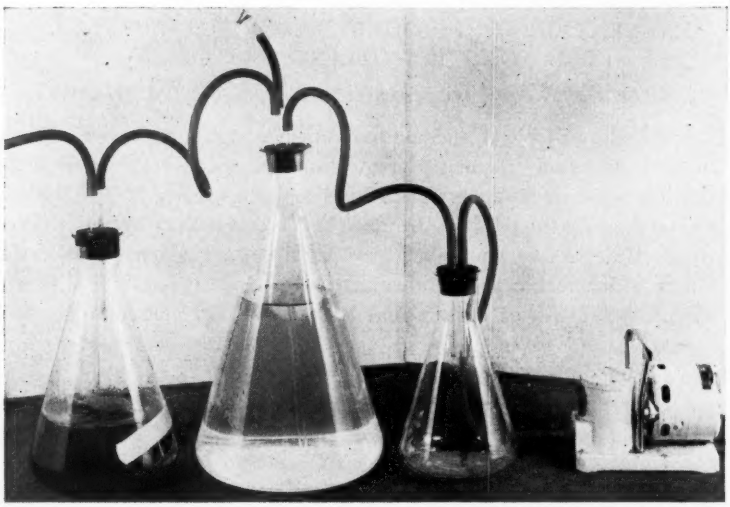

Fig. 2.—Appearance immediately after addition of 0.5 c.c. of caprylic alcohol. All bubbles are immediately destroyed and further foaming is prevented.

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THE REMOVAL OF BENIGN PEDUNCULATED INTRA-ATRIAL TUMORS: A CLOSED SURGICAL APPROACH

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OUR operative experience with intra-atrial tumors at the Bailey Thoracic Clinic consists of 5 cases. In none was the correct diagnosis made preoperatively. In all cases the tumor was encountered during exploration for suspected mitral valve disease, either at our Clinic or at another institution. All of our attempts at surgical removal have resulted in mortality except in the last patient operated. We were not successful in removing the tumor in its entirety even in the last case. However, the operative method used was defeated because of the exceedingly large size of the tumor plus a defect in the instrument used. We feel that the tumor in our last case was much larger than will usually be found, if the smaller tumors we had previously encountered can be used as an indication of the average. We also feel that the defect in the instrument has now been corrected.

Since many patients with suspected mitral valvular disease are now being operated upon at various clinics, more and more surgeons undoubtedly will encounter an occasional intra-atrial tumor. To date the only report of a successful removal is that of Crafoord,[1] who used hypothermia and an open technique. Since it usually is not feasible to induce hypothermia once a closed type of intracardiac operation has been undertaken, it is our hope that the closed method we used in the last patient will prove helpful in removing such tumors.

All of the cases of intra-atrial tumors that we have encountered occurred within the left atrium, and have been diagnosed as benign myxomas by microscopic examination (Fig. 1). In all cases, the pedicle was attached at the rim of the fossa ovalis. It was easy to separate the pedicle from its septal attachment by blunt digital dissection. These tumors (Fig. 2) were soft and friable, and attempts at mechanical removal of them presented the great problem of fragmentation with resulting embolism. We, therefore, designed an instrument† which could be inserted into the atrium along the index finger through the purse-stringed atrial appendage. The end of the instrument contains a band of spring steel to which a meshed nylon bag is attached much like a fish net (Fig. 3 *A*, *B*, *C*, and *D*). By drawing upon the sliding shaft at the opposite end of the instrument, the diameter of the band's circle is reduced and the mouth of the net becomes puckered so that it can easily be

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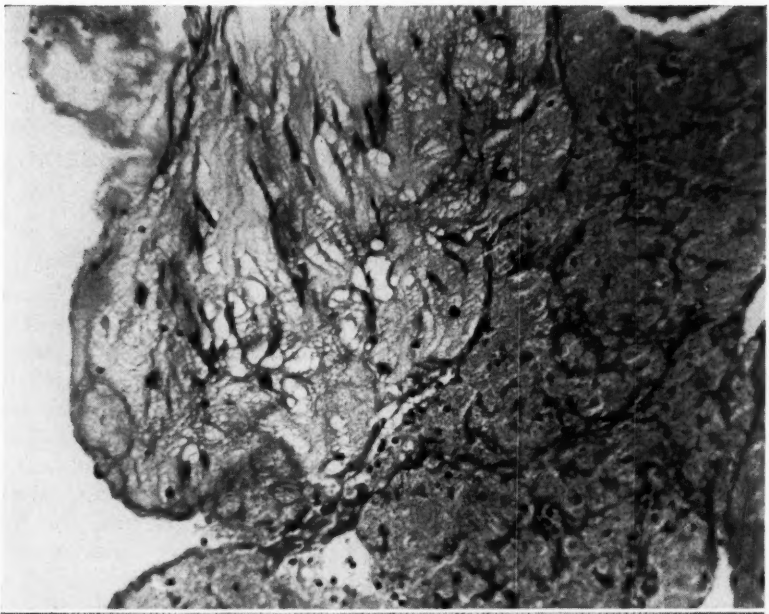
†Obtainable from George P. Pilling & Son Co., Philadelphia, Pa.

Fig. 1.



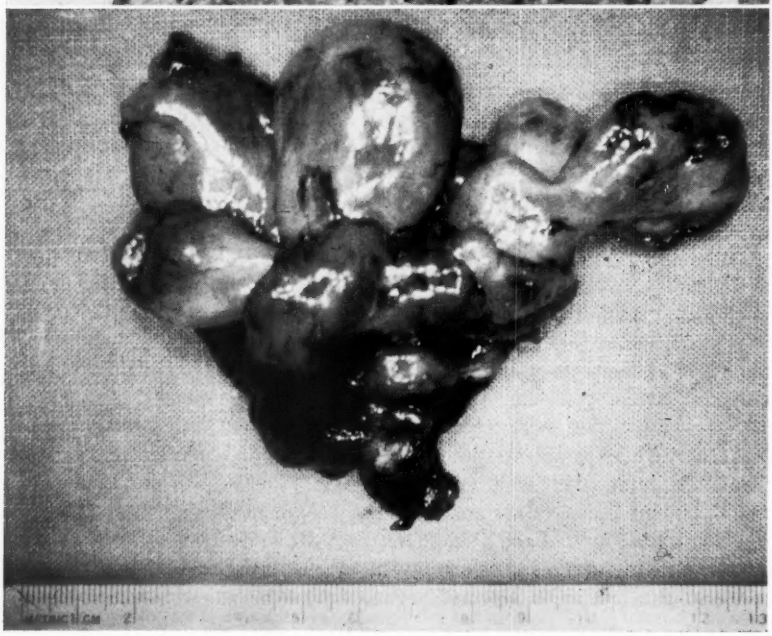


Fig. 2.

Fig. 1.—Photomicrograph of myxoma removed from left atrium. (×80; reduced ⅕.)
Fig. 2.—A typical gross specimen of an intra-atrial myxoma showing a small pedicle and multiple lobulations.

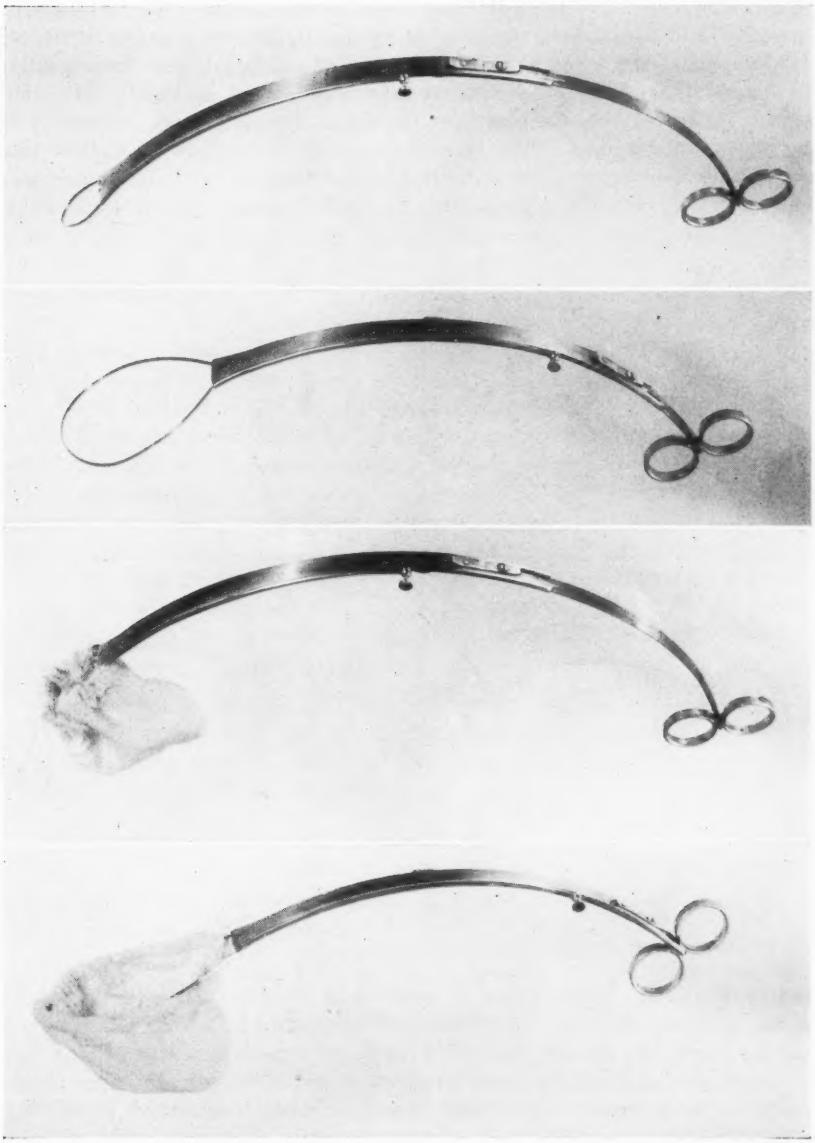


Fig. 3.—*A*, Instrument with band of snare retracted. *B*, Instrument with band of snare extended. *C*, Same as *A* with nylon "fish net" attached. *D*, Same as *B* with nylon "fish net" attached.

inserted alongside the operator's intracardiac finger into the atrium (Fig. 4, *A*). After the end of the instrument, plus its attached net, has been passed completely into the atrium, the band is opened to provide a large mouth to the "fish net." The index finger then is used to manipulate the tumor gently into the net (Fig. 4, *B*). After all of the tumor, except its pedicle, has been trapped within the net, the mouth of the net is partially closed so that it is snug around the pedicle. The edge of the band then is pushed against the septum while counter pressure is applied by the finger to the other side of the pedicle (Fig. 4, *C*). Thus, the pedicle is scooped from its attachment to the

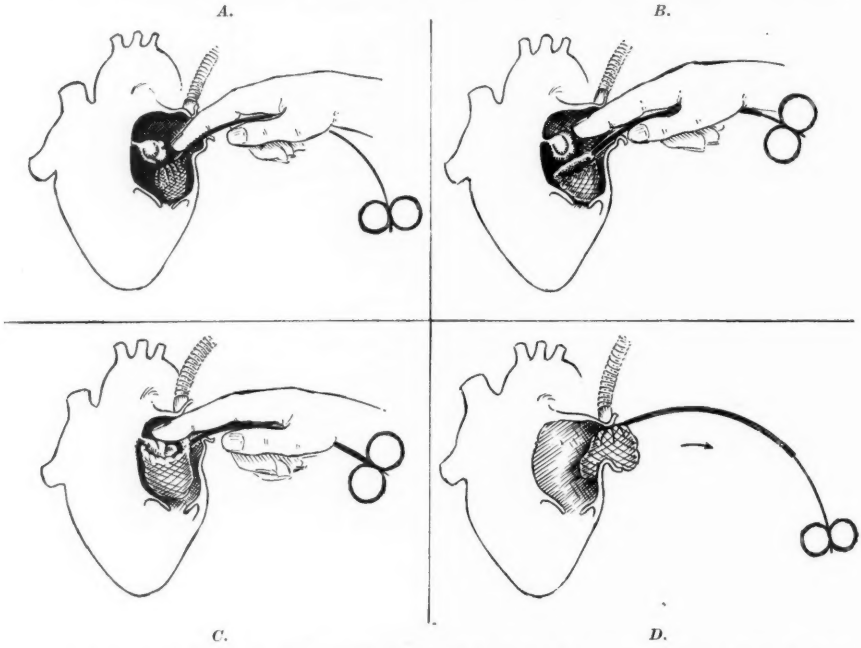


Fig. 4.—*A*, Instrument in place inside atrium with snare closed. *B*, Snare open so that finger can gently manipulate myxoma into "fish net." *C*, Myxoma in "fish net" and pedicle being scooped from attachment at atrial wall. *D*, Myxoma completely enclosed in net and being extracted through opening in atrial appendage.

septal wall and the entire tumor is forced into the net. Then, the mouth of the net is closed tightly. The finger and the instrument are then removed from the heart. As the net is pulled through the atrial appendage (Fig. 4, *D*), the tumor probably will be much larger than the opening in the appendage, but due to its gelatinous consistency it can be easily fragmented, permitting its shape to be altered for easy extraction. Since it is completely enclosed within the net, there is no danger of embolization from such fragmentation.

We utilized the instrument and technique just described on April 5, 1955, at the Hahnemann Hospital, Philadelphia, in a 41-year-old white man (O.S., Hosp. No. 55-03375), who presented symptomatology of increasing exertional

dyspnea, nocturnal dyspnea, orthopnea, fatigue, and peripheral edema over a period of twelve years. At the time of surgery, he was no longer able to work. At surgery, the tumor was found to arise from a pedicle attached to the interatrial septum and consisted of multiple lobules which almost completely filled the left atrium. We were able to manipulate a good two thirds of the tumor into the net, but because of its size there was still one lobule, located cephalad and farthest from the mitral valve, which we could not force into the net for fear of fragmentizing it. Thus, we removed that part of the tumor which we could safely net. On extreme tightening of the mouth of the net, the metallic band separated at its welded attachment from the end of the instrument. Therefore, we were not able to use the instrument again to remove the remnant of tumor. Since this unfortunate occurrence, we have redesigned the instrument so that the band is no longer welded to the instrument at one end, but is now a replaceable unit like the wire of a tonsil snare. The weak point of welding is eliminated as a possible breaking point, and even should the band break it can be replaced immediately.

Since we had excised that portion of the tumor lying immediately above the mitral valve, we had hopes that the patient would be improved even by this partial removal. Three months following surgery, the patient had had no recurrence of exertional dyspnea, nocturnal dyspnea, or fatigue. He was able, for the first time in months, to sleep flat in bed, and had returned to work. Since his twelve-year history of increasing symptomatology suggests that the tumor was growing slowly over the same period, we can only hope that he will have several years of freedom from symptoms before requiring further surgery.

SUMMARY

A closed surgical technique for the removal of intra-atrial tumors is presented. Our experience with one operative case in which the major part of the tumor was successfully removed is presented.

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PROCAINE AMIDE IN HYPOTHERMIA

An Experimental Study

G. E. Mavor, M.D., Ch.M., R. A. Harder, M.D., G. L. Emerson, M.D., and E. B. Mahoney, M.D.,
Rochester, N. Y.

PROCAINE AMIDE has been used clinically in the treatment of auricular and ventricular arrhythmias as, in adequate dosage, it will depress the excitability of both auricular and ventricular muscle.[9] Furthermore, the drug will completely protect the dog heart in situ against electrically induced auricular fibrillation and will also afford a large measure of protection to the ventricles.[8] In certain instances, it has been used in the successful prevention of ventricular fibrillation.[3, 4, 6] The mortality attending the induction of experimental hypothermia has been related to the high incidence of ventricular fibrillation occurring spontaneously during cooling or in the course of circulatory arrest.[1] Although this may be in some degree related to the development of hypercapnia during cooling or to sudden variations in pH levels thereafter,[7] the basic biochemical changes in the myocardial cell are not yet known. Careful electrocardiographic studies in the hypothermic dog indicate that the onset of ventricular fibrillation is preceded by the development of extrasystolic activity although this phase may be so transient that visual appreciation is difficult or impossible. Although unlikely that procaine amide used in such a situation would have any beneficial effect, its trial, both in the prevention and treatment of ventricular fibrillation in the hypothermic dog, seemed warranted.

PRESENT INVESTIGATION

Twenty-five dogs of an average weight of 14 kg. were used in this study, 10 as controls and 15 with procaine amide administered. Under Pentothal sodium* anesthesia, which was also used to control shivering, hypothermia was induced by surface cooling in an ice bath at 4° C. The rectal temperature range obtained was 25 to 30° C. Controlled respiration at a ventilation rate of 24 per minute was maintained by a mechanical respirator using oxygen at 500 ml. per minute in a closed circuit. A soda lime CO_2 absorber was included in the circuit during cooling. Four of the dogs were cooled without caval occlusion. Twenty-one animals underwent a right thoracotomy and caval occlusion with circulatory arrest for periods of 2 to 12 minutes. A right auriculotomy was routinely performed during caval occlusion. Rewarming was carried out to 96° C. by immersion in a water bath at 45° C.

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*The Pentothal sodium used in this study was supplied by Abbott Laboratories, North Chicago, Ill.

Procaine amide was administered by continuous intravenous infusion in concentration of 0.2 Gm. per cent, each dog receiving a minimum of 0.8 Gm. before the commencement of occlusion. In 5 dogs in the treatment of ventricular fibrillation, the drug was given locally into the ventricle or into the arch of the aorta which was clamped above the site of injection, allowing the drug to be perfused through the coronary system by cardiac massage.

RESULTS

Incidence of Ventricular Fibrillation.—No procaine amide. Of the 10 dogs cooled without procaine amide administration, ventricular fibrillation occurred in 4; 1 before caval occlusion, and 3 in the course of caval occlusion with auriculotomy or on release of the caval clamps (Table I). The 6 remaining dogs had caval occlusion periods of from 7 to 10 minutes with normal cardiac function restored. The arterial CO_2 levels of the 9 dogs without fibrillation before circulatory arrest showed considerable variation, as did those of the dog in which fibrillation occurred (Fig. 1).

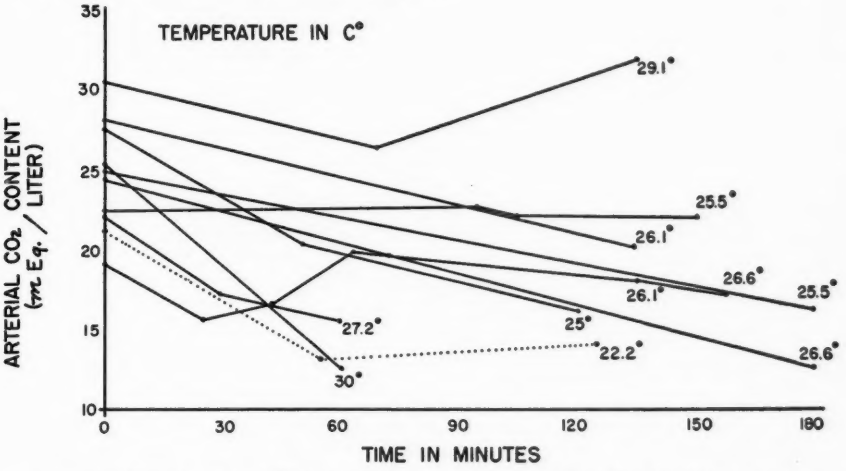

Fig. 1.—Control series of 10 dogs showing variations in arterial CO_2 levels during cooling. No procaine amide was administered. The figures represent lowest temperature reached. All points are before caval occlusion. The dotted-line curve represents the dog in which fibrillation did occur.

TABLE I. INCIDENCE OF VENTRICULAR FIBRILLATION

No procaine amide.—		
Number of dogs	10	
Ventricular fibrillation	4	
a. before caval occlusion		1
b. during caval occlusion		1
c. after caval occlusion		2
With procaine amide.—		
Number of dogs	15	
Ventricular fibrillation	4	
a. before caval occlusion		1
b. during caval occlusion		0
c. after caval occlusion		3
Ventricular bradycardia and arrest	2	

Incidence of Ventricular Fibrillation.—With procaine amide. Of 15 dogs with procaine amide administration during cooling, ventricular fibrillation occurred in 1 before caval occlusion. Of the first 6 dogs with caval occlusion and auriculotomy, ventricular fibrillation occurred in 3 on release of the caval clamps, cardiac arrest in 1 after a 12-minute period of caval occlusion, and irreversible bradycardia (8 per min.) in 1 after 9 minutes of occlusion.

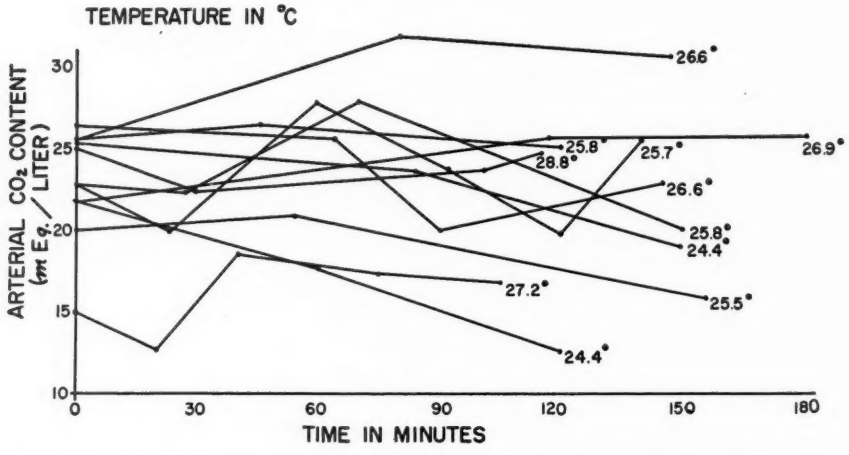

Fig. 2.—Variations in arterial CO_2 levels during cooling with no ventricular fibrillation. Procaine amide was administered.

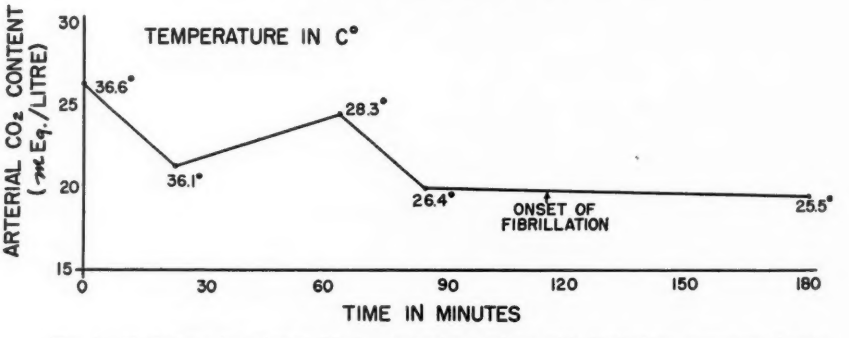

Fig. 3.—Variations in arterial CO_2 levels during cooling with fibrillation occurring despite procaine amide administration. The onset of fibrillation which occurred before occlusion is indicated by the arrow.

Because of these results, the remaining 9 dogs in this group had short circulatory arrest periods of 2 minutes, before resuscitation was undertaken by the use of potassium (Table I). Of the 11 dogs without fibrillation, 5 cases showed wide variations in CO_2 and pH levels at different periods of cooling, while 6 had adequately controlled CO_2 and pH values (Fig. 2). Of the 3 dogs with fibrillation at the release of caval clamps, 1 showed a uniform CO_2 level during cooling, while 2 showed a fall in CO_2 levels (Fig. 3).

Treatment of Ventricular Fibrillation.—In the treatment of ventricular fibrillation, procaine amide was injected into the left ventricle and into the aorta to perfuse the coronary system. The doses administered were 50, 100, and 150 mg. In 5 animals, the drug given in these amounts had no beneficial effect on the existing fibrillation, either clinically or electrocardiographically. After 50 mg. and 100 mg. doses, no change was noted on the electrocardiogram, while in 2 cases, a 150 mg. dose slowed the ventricular fibrillation wave, producing a clinical slow "wave" fibrillation (Fig. 4). This ventricular activity could not be altered by prolonged massage or by the empirical use of epinephrine or calcium.

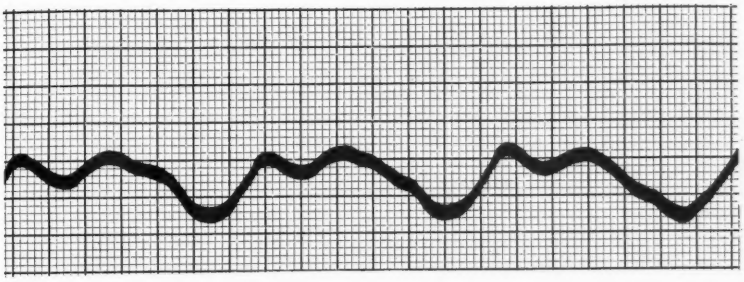

Fig. 4.—Electrocardiogram (Lead 2) of clinical slow "wave" fibrillation (25 mm. per sec. and 1 millivolt per cm.)

Cerebral Anoxia.—From our experience at the temperature range of 25 to 30° C., 20 minutes has been regarded as the critical limit for circulatory arrest. With periods over this time, sufficient cerebral damage apparently occurs to prevent the animal regaining consciousness although reflex and medullary activity returns. This period of cerebral anoxia is a summation of the time of caval occlusion and the period from the end of occlusion until the production and maintenance of an arterial pressure of 40 mm. Hg or more by cardiac massage.

In 6 dogs receiving procaine amide, the period of calculated cerebral anoxia was 5, 8, 12, 15, 17, and 19 minutes, respectively. These 6 animals did not regain consciousness, living in an unconsciousness state for varying periods up to 48 hours. Post-mortem examination showed bronchopneumonia in 4 dogs, and no helpful findings in the others. The brain was not examined.

DISCUSSION

It has become evident from our experience that spontaneous ventricular fibrillation may occur during cooling in the presence of adequately controlled CO_2 and, thus, pH levels (Fig. 5). Furthermore, in this study, in both control dogs and in dogs receiving procaine amide in which fibrillation did not occur prior to caval occlusion, the CO_2 levels in the majority showed considerable variation at different periods of the experiment (Figs. 2 and 3). It seems a justifiable conclusion that changes in CO_2 are not the fundamental cause of ventricular fibrillation, although sudden variations may accentuate some causal biochemical shift in regard to the myocardial cell. However, procaine

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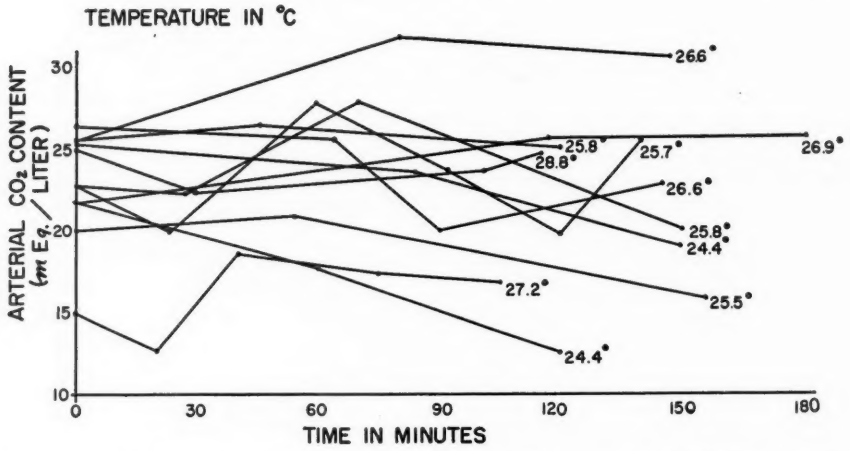
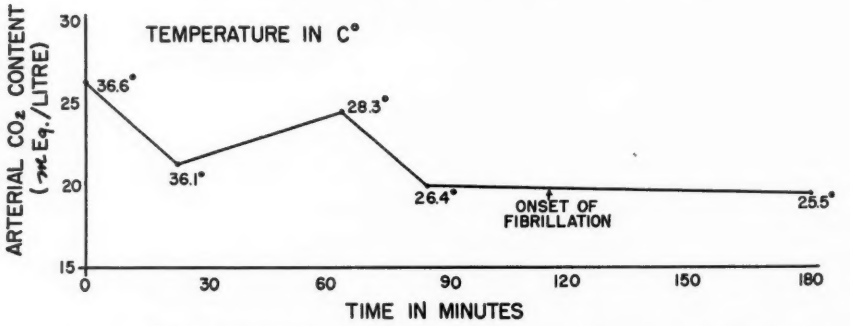


Fig. 2.—Variations in arterial CO_2 levels during cooling with no ventricular fibrillation. Procaine amide was administered.



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Because of these results, the remaining 9 dogs in this group had short circulatory arrest periods of 2 minutes, before resuscitation was undertaken by the use of potassium (Table I). Of the 11 dogs without fibrillation, 5 cases showed wide variations in CO_2 and pH levels at different periods of cooling, while 6 had adequately controlled CO_2 and pH values (Fig. 2). Of the 3 dogs with fibrillation at the release of caval clamps, 1 showed a uniform CO_2 level during cooling, while 2 showed a fall in CO_2 levels (Fig. 3).

Treatment of Ventricular Fibrillation.—In the treatment of ventricular fibrillation, procaine amide was injected into the left ventricle and into the aorta to perfuse the coronary system. The doses administered were 50, 100, and 150 mg. In 5 animals, the drug given in these amounts had no beneficial effect on the existing fibrillation, either clinically or electrocardiographically. After 50 mg. and 100 mg. doses, no change was noted on the electrocardiogram, while in 2 cases, a 150 mg. dose slowed the ventricular fibrillation wave, producing a clinical slow "wave" fibrillation (Fig. 4). This ventricular activity could not be altered by prolonged massage or by the empirical use of epinephrine or calcium.

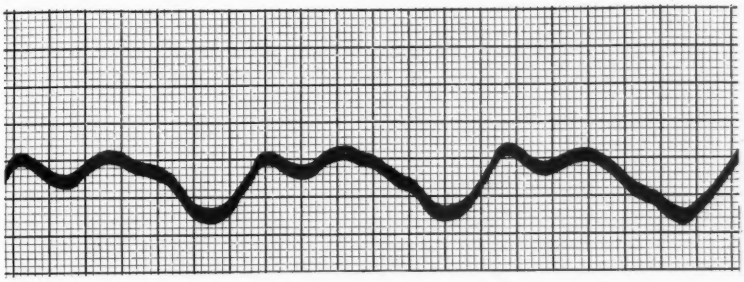

Fig. 4.—Electrocardiogram (Lead 2) of clinical slow "wave" fibrillation (25 mm. per sec. and 1 millivolt per cm.)

Cerebral Anoxia.—From our experience at the temperature range of 25 to 30° C., 20 minutes has been regarded as the critical limit for circulatory arrest. With periods over this time, sufficient cerebral damage apparently occurs to prevent the animal regaining consciousness although reflex and medullary activity returns. This period of cerebral anoxia is a summation of the time of caval occlusion and the period from the end of occlusion until the production and maintenance of an arterial pressure of 40 mm. Hg or more by cardiac massage.

In 6 dogs receiving procaine amide, the period of calculated cerebral anoxia was 5, 8, 12, 15, 17, and 19 minutes, respectively. These 6 animals did not regain consciousness, living in an unconsciousness state for varying periods up to 48 hours. Post-mortem examination showed bronchopneumonia in 4 dogs, and no helpful findings in the others. The brain was not examined.

DISCUSSION

It has become evident from our experience that spontaneous ventricular fibrillation may occur during cooling in the presence of adequately controlled CO_2 and, thus, pH levels (Fig. 5). Furthermore, in this study, in both control dogs and in dogs receiving procaine amide in which fibrillation did not occur prior to caval occlusion, the CO_2 levels in the majority showed considerable variation at different periods of the experiment (Figs. 2 and 3). It seems a justifiable conclusion that changes in CO_2 are not the fundamental cause of ventricular fibrillation, although sudden variations may accentuate some causal biochemical shift in regard to the myocardial cell. However, procaine

amide has not been successful in preventing fibrillation in the presence of changes in CO_2 levels (Fig. 3), and this seems adequate evidence against any assumption that the low incidence of fibrillation during cooling in this study was due to the administration of the drug.

In dogs at normal body temperature, procaine amide in large doses has produced similar effects on the heart to those noted here.[9] In the hypothermic dog, particularly in the presence of circulatory arrest, the effects of the drug are likely to be more marked and more prolonged. Thus, it is of importance that in the treatment of ventricular fibrillation, no slowing of fibrillation has been noted as a prelude to impending slow "wave" fibrillation. In other words, there has been no visual or electrocardiographic evidence of the approaching toxic effect of the drug.

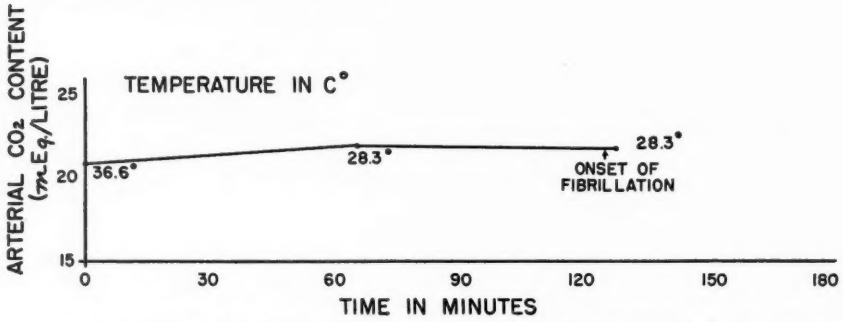

Fig. 5.—Stable arterial CO_2 levels during cooling with fibrillation occurring. No procaine amide was administered. The onset of fibrillation before caval occlusion is indicated by the arrow.

The main effect of procaine amide is a direct one on the auricle. In the denervated heart it depresses sinus action and may eventually produce sinus arrest with nodal rhythm.[9] Although it may also depress the excitability of both auricle and ventricle, its main action in the case of the latter appears to be on diminishing the speed of conduction.[8, 9]

The damage to intraventricular conduction which procaine amide causes may facilitate the re-entry of impulses and the onset of ectopic activity.[9] The circumstance thus arises that procaine amide, which may suppress ventricular automatism when it is established, may lead in the increasing dose to abnormal ventricular activity and fibrillation. With these considerations in mind, it seems unjustifiable to use the drug when circulatory arrest is contemplated, as at this time myocardial ischemia and coronary hypercapnia may already be slowing conduction, and procaine amide may become an additional factor in causing further damage. The position appears to be that as regard to the hypothermic heart, where circulatory arrest is not contemplated, procaine amide will do neither good nor harm, but where occlusion of the inflow tracts is carried out, the use of the drug has serious drawbacks without having, at least experimentally, any obvious advantages.

Cerebral Effects of Procaine Amide.—Although no direct reference could be found in the literature to the effects of hypoxia or hypothermia on the use of procaine amide, there would seem little doubt that both these factors will

potentiate the action of the drug. Though less pronounced than those of procaine, the effects of procaine amide on the central nervous system show the same pattern of initial excitation followed by a more prolonged depressant action. In addition to these central effects, depression of systemic blood pressure levels may result from large rapid intravenous doses. Death is usually caused by respiratory arrest.[5, 6] The drug is slowly hydrolyzed in the plasma with 60 per cent excreted unchanged by the kidneys except in the presence of renal impairment or congestive heart failure.[2]

Although in this study procaine amide was infused at a slow rate (between 5 to 7 mg. per minute), the presence of generalized hypothermia combined with circulatory arrest might conceivably produce a cumulative toxic effect as both detoxification and excretion of the drug will be impaired. The 6 dogs in this series with periods of cerebral anoxia of less than the critical limit of 20 minutes did not regain consciousness although reflex activity and spontaneous respiration were present on initial rewarming. Thereafter, death occurred with respiratory failure preceding any evidence of cardiovascular collapse.

SUMMARY

1. Procaine amide, administered by continuous intravenous infusion in concentrations of 0.2 Gm. per cent, did not prevent the occurrence of ventricular fibrillation in 4 dogs out of a group of 15 subjected to circulatory arrest under hypothermia.

2. Intracardiac injection and coronary perfusion of 1 per cent procaine amide solution did not arrest fibrillation, but converted the ventricular myocardium into a nonremedial state of slow conduction which was manifest clinically and electrocardiographically.

3. Presumptive evidence is presented that procaine amide has caused toxic effects on the hypothermic brain resulting in failure of the dogs to regain consciousness, despite the fact that in these dogs the period of cerebral hypoxia in the temperature range 25° to 30° C. was within the known critical limit of 20 minutes.

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NEURILEMMOMA OF THE DIAPHRAGM

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A RAPIDLY increasing scope of thoracic surgical procedures has been reflected by the accruing literature concerning the intriguing and challenging primary tumors and cysts of the diaphragm.[1-6, 9, 12, 15] Particular surgical interest in these lesions was stimulated by the report by Gale and Edwards,[7] in 1939, of a successful excision of a malignant tumor of the diaphragm. By 1950, Samson and Childress[11] accumulated 33 well-authenticated cases of primary tumors from the literature and reported 2 cases of neurofibrosarcoma of the diaphragm, in one of which the tumor was successfully resected. The first primary neurogenic tumor of the diaphragm was apparently reported by Klassen, Patton, and Bemen,[10] in 1945, when they described the successful excision of a large neurofibroma of the diaphragm. Since that time, three other neurogenic tumors have been recorded,[11, 14] two of which were surgically removed. We have not found a previous recorded case of diaphragmatic neurilemmoma, and that fact, in addition to the rarity of the lesion and the interesting clinical picture presented by the patient, has occasioned the following case report.

CASE REPORT

W. B., C. H. 218283, a 55-year-old white housewife, was first seen in consultation on March 24, 1954, because of a severe dry cough and pain in the left chest and arm. The patient had been treated for heart disease and angina for the previous five years. Except for gradually increasing exertional dyspnea there were no other pertinent symptoms and the patient denied hemoptysis, expectoration, and wheezing.

A review of the family history was significant in that the patient's father had died of pulmonary tuberculosis at the age of 40 years and her mother had died at 68 years of heart trouble. Her past history revealed that she had had cholecystectomy performed in 1924, two attacks of left-sided pleurisy, and a tonsillectomy in 1926, and vein ligations of the right leg in 1948.

Physical examination showed a rather apprehensive woman in moderate respiratory distress. Her weight was 167 pounds, the blood pressure 130/90, pulse rate 116 and irregular, and respirations 24. There was dullness to percussion over the right lower chest. The thyroid was moderately enlarged and nodular. Both legs showed a grade 2 pitting edema and varicose veins were present over the right leg. No evidence of digit clubbing was present.

Roentgen and fluoroscopic examinations of the chest and abdomen (Fig. 1) showed a marked density in the left lower chest with an elevated left hemidiaphragm which on normal, slow respiration appeared to move slightly but on sniffing showed a moderate paradoxical movement. Various changes of position including lateral decubitus produced no alteration of the roentgen picture, and studies with and without opaque media demonstrated increased distance between the diaphragm and stomach and colon.

Bronchoscopy was performed under local anesthesia on March 27, 1954. The pertinent findings were a mucoid plug in the left lower lobe bronchus, elevation of that bronchus, and moderate narrowing apparently due to extrinsic pressure. Thoracotomy was con-

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sidered advisable at this time for exploration of an intrathoracic or subdiaphragmatic lesion but because of the patient's general condition and the diagnosis of heart disease with failure, operation was held in abeyance pending further evaluation and study.

In November, 1954, the patient was seen in consultation by one of us (D. M. W.) because of marked cardiac irregularity. The chest pains were noted to be of 12 years' duration, were located in the left subclavicular area and radiated to the deltoid area. They were described as "terrible shooting pains that last for days" which kept the patient from doing her work and were partially relieved by rest and aspirin. There was an associated nonproductive cough attributed to a "bad cold" twelve years previously which had been constantly present since that time except for amelioration during the warm summer months. Paroxysms were precipitated by exposure to cold air and by physical exertion.

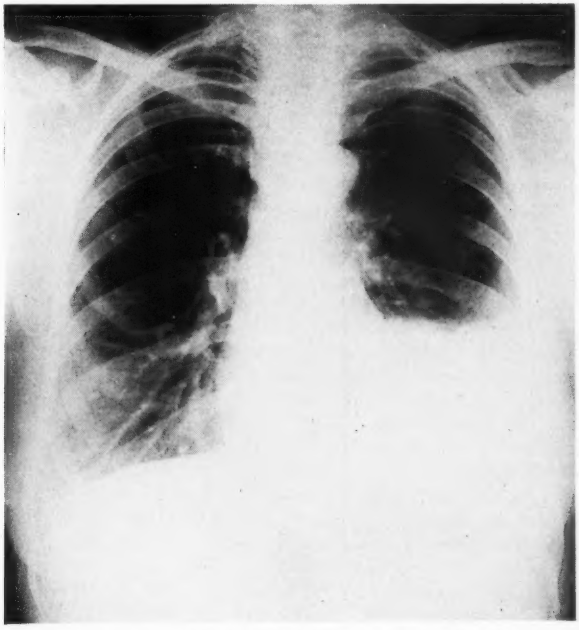


Fig. 1.——Posteroanterior roentgenogram of the chest showing increased density of left lower chest.

Awareness of irregular cardiac action was of four months' duration. It was described as a sensation as though the "heart would jump out of my throat" and was aggravated by activity and dyspnea. Extreme weakness and diminished exercise tolerance were also prominent symptoms.

Functional aspects of her disability included the fact that her mother had "this same kind of a heart cough" for many years before her death. The patient raised six children and two grandchildren and was responsible for the major work on a farm on the outskirts of a small city in which her husband was employed. She acknowledged marked "nervousness," drank a minimum of 12 cups of black coffee daily, and suffered considerably from insomnia.

Examination revealed a depressed, worn-out appearing, stooped, disillusioned woman who appeared older than her stated age. Throughout the interview she sighed a great deal. Her weight was 139½ pounds, the blood pressure 116/72, and pulse was 80 with

multiple premature contractions. A moderately enlarged nodular thyroid was present, but no signs of hyperthyroidism could be detected. The heart was normal in size and the heart sounds were normal in character including examination at the base during expiration, and at the apex in the left lateral decubitus after exercise. Physical examination of the lungs revealed dullness and impaired breath sounds at the left base but no evidence of fluid. There was moderate edema limited to the right leg which was the site of extensive varicosities. A 12-lead electrocardiogram revealed multiple premature contractions of ventricular origin, a rate of 58, and no other abnormalities. A teleoroentgenogram revealed no enlargement or displacement of the cardiac silhouette.

Diagnoses were: (1) pulmonary lesion left base of unknown nature; (2) premature contractions of an irritable heart but no objective evidence of organic heart disease; (3) nontoxic nodular goiter; and (4) chronic anxiety tension state aggravated by the consumption of excessive amounts of coffee.

Symptomatic administration of quinidine sulphate and salicylate preparations gave some relief. The patient failed to reduce her intake of coffee and the preponderance of symptoms that appeared to be of functional origin and to be related to a respiratory alkalosis of chronic hyperventilation and to poor posture discouraged exploratory thoracotomy.

She was re-admitted to the hospital on April 1, 1955, because of a marked increase in symptoms of dyspnea, cough, chest pain, palpitations, and swelling of the legs. Physical findings were essentially as described previously except for an increase in the left thoracic dullness and corroborative roentgen findings of an increasing pleural effusion and an acute thrombophlebitis involving the right leg.

Clinical findings of importance were a hemoglobin of 13.5 Gm., the red blood cells numbered 4.54 million, white-blood cells 5,650, and a differential count was within normal limits. The sedimentation rate was 29, the serum bilirubin 0.6 mg. per cent. The total protein was 6.68 Gm. per 100 c.c. of which 3.9 Gm. were albumin and 2.78 Gm. were globulin, or a ratio of 4:3. Examination of 500 c.c. of an amber pleural fluid removed showed a specific gravity of 1.023, a cell count of 10 to 20 red blood cells per high-powered field, 2 to 5 white blood cells of which 11 per cent were polymorphonuclear leukocytes and 89 per cent lymphocytes. No malignant cells were seen in the sediment. Fluoroscopic and roentgen findings were as described previously. Electrocardiographic studies were essentially normal except for premature ventricular beats and the cardiac evaluation at this time was suggestive of no serious organic heart disease. Bronchoscopy was repeated with similar findings to those just described.

A left thoracotomy was performed on April 29, 1955, utilizing a posterolateral incision. The left seventh rib was resected and the pleural space was entered through the periosteal bed. A huge mass was found filling the left lower thorax and compressing and adherent to the lower surface of the left lung and the pericardium. The surface of the mass was covered with large vessels and after careful extensive dissection the tumor was found to arise from a pedicle about 4 inches in diameter in the dome of the left leaf of the diaphragm. The tumor derived its blood supply from the pericardiophrenic and inferior phrenic vessels. The mass was separated from the chest wall, diaphragmatic surface of the lung, and pericardium by sharp and blunt dissection. The central portion of the diaphragm was excised with the tumor and both were then removed. The diaphragmatic defect was repaired by closing the two edges of the defect with interrupted cotton sutures. Hemostasis was secured and the chest wound was closed with intrapleural, subaqueous drainage.

The patient's convalescence was uneventful except for a slow re-expansion of the left lower lobe. She was discharged to her home on May 13, 1955. Follow-up examinations have shown a progressive improvement in the patient's symptoms and general condition. Her heart has been slow and regular without medication and her dyspnea has disappeared. She continues, however, to complain of intermittent left shoulder and chest wall pain but of much less degree than the preoperative pain. Follow-up x-rays have shown a normal postoperative chest (Fig. 2).

Fig. 2.—Posteroanterior and left lateral roentgenograms of the thorax demonstrating disappearance of left lower chest density, surgical absence of left seventh rib, change in heart silhouette, and postoperative pleural alterations in the left thorax.

PATHOLOGIC DESCRIPTION

Gross Description.—The specimen consisted of a large ovoid tumor which measured 11 by 18 by 23 cm. and weighed 1,390 Gm. (Fig. 3). The external surface presented a variegated appearance. There was apparent encapsulation but many glistening nodules of violaceous, edematous tissue ranging from 0.3 to 5.0 cm. in diameter were scattered over the surface. Small pieces of striated muscle and parts of the central tendon of the diaphragm were on the surface where the pedicle had been dissected free. Areas of the surface between nodules were tan, firm, and quite dense.

The cut surface exposed two dissimilar types of tissue present in approximately equal amounts but irregularly distributed. The solid areas of the specimen were composed of light tan, fibrous, resilient, spheroidal nodules which bulged above a thin membranous pseudocapsule. The resemblance of these nodules, varying from 1.0 cm. to 10.0 cm. in diameter, to uterine leiomyomas was striking. Occasional small yellowish areas were also seen.

The remainder of the cut surface consisted of moist, red-purple, delicately fibrous tissue which contained many small cysts up to 2 cm. in diameter. Direct continuity was seen in many places between the violaceous nodules upon the external surface and similar tissue within the tumor.

Microscopic Examination.—Blocks of tissue were removed from more than thirty-six different areas of the specimen. Paraffin sections were prepared and were stained with hematoxylin and eosin, Gömöri's trichrome stain, Wilder's silver reticulin stain, Verhoeff's elastic stain, van Gieson's connective tissue stain, and with phosphotungstic acid-hematoxylin. Frozen sections were also prepared from representative areas of the fresh specimen and were stained with Terry's stain (polychrome methylene blue), or with Sudan IV for fat.

As noted upon gross examination, microscopy revealed two dominant histologic patterns. Sections from the solid areas were composed of tightly packed, well-differentiated, fusiform or filiform cells arranged in interlacing bundles. Occasionally, the nuclei were palisaded forming ill-defined Verocay bodies. There were no giant cells or mitoses, but scattered foam cells containing sudanophilic vacuoles were noted in some areas. The staining reactions of the tumor cells with the various stains were those of delicate connective tissue (not collagen) rather than smooth muscle (Fig. 4).

The remaining areas of the tumor were very cellular, but the cells were small without defined cytoplasmic borders; the stroma was edematous, almost myxoid, with scattered cysts arising from colliquative necrosis (Fig. 5).

Sections through the pedicle contained tumor, fragments of normal striated muscle, and pieces of the central tendon.

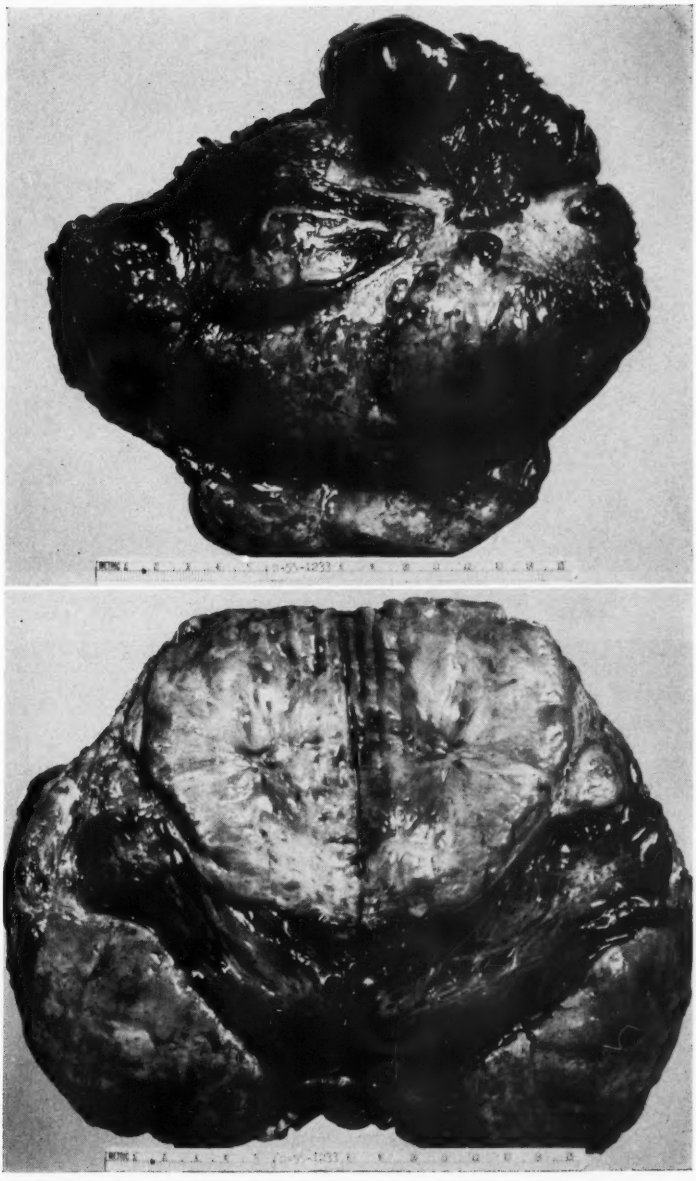
The pathologic diagnosis was benign neurilemmoma arising from the pleural surface of the left leaf of the diaphragm.

DISCUSSION

In his classification of the peripheral nerve tumors, Stout[13] has grouped the neurilemmoma as a benign, neuro-ectodermal neoplasm of supportive tissue type, or a tumor of nerve sheath origin. He lists as synonyms of this tumor the following: neurilemmoma, angioneurofibroma, false neuroma, fibroganglioma, acoustic neuroma, fibromyxoma, glioma, myoschwannoma, neurilemoblastoma, neurinoma, neurofibromyoma, neuroma fibrillare, peripheral glioma, perineural fibroblastoma, perineural glioma, Schwannoma, Schwannoglioma and specific nerve sheath tumor.

It is obvious from this foregoing list of synonyms that lesions of this type have been described by numerous authors and have been found in many locations, including the thorax.[8] Most of the gross descriptions of tumors have

A.



B.

Fig. 3.—*A*, External appearance of tumor showing irregular surface with large and small cysts, nodules, and dilated blood vessels. *B*, Cut surface of tumor demonstrating lobular division of tumor by mucoid septa.

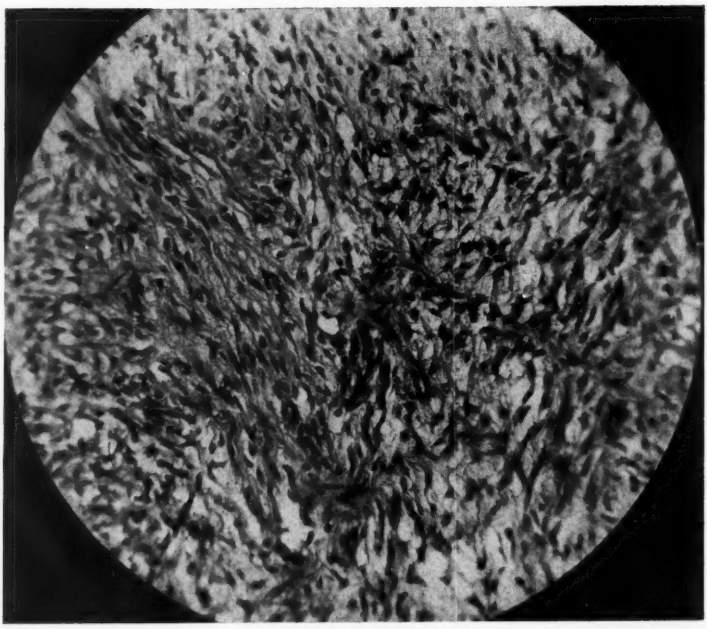


Fig. 4.—Microscopic section demonstrating Antoni type A pattern with well-differentiated filiform and fusiform cells, interlacing bundles, and palisading nuclei (×75).

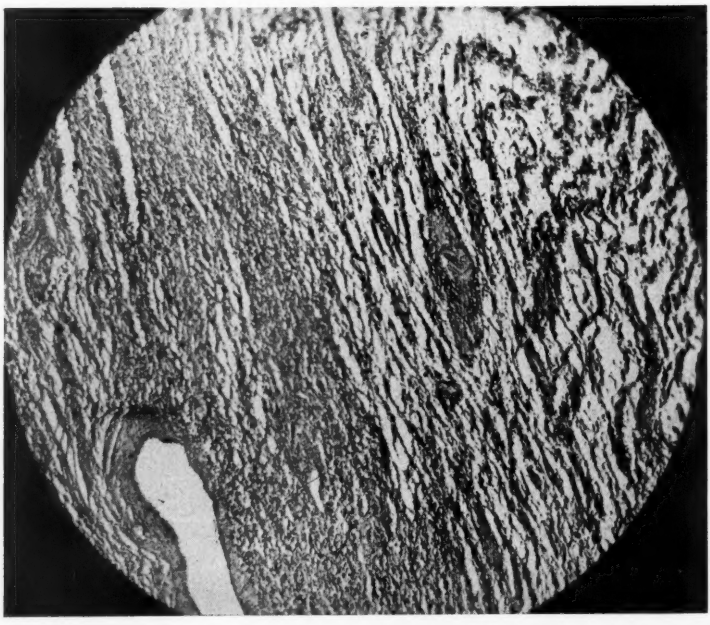


Fig. 5.—Histologic section of Antoni type B area, showing cellularity, myxoid stroma, large nuclei, and haphazard tissue arrangement (×45).

corresponded to that reported herein and the encapsulated variety has been considered most frequently to be benign. The histologic picture has been characteristic and two microscopic patterns consisting of a solid complex, the Antoni type A, and a cystic or loose complex, the Antoni type B, have been the most common.[13]

The symptoms and signs exhibited by this patient have been similar to those previously described. The shoulder and arm pains were apparently due to diaphragmatic irritation. The cough could have been due to pleural and bronchial derangement, while the exertional dyspnea could well have been the result of mechanical interference with respirations.

The diagnosis of this tumor was dependent on the surgical exploration of the thorax, and although pneumothorax and pneumoperitoneum were not performed, it was not felt that they would have added to the roentgen survey described. In retrospective consideration, the patient should have been operated upon sooner and would have been if the nature of her disability had been understood and the functional aspects of her disability had created less of a problem.

The patient's postoperative course has been singularly favorable and, in view of the benign character of the lesion, an excellent prognosis should be her outlook.

SUMMARY

1. A primary neurilemmoma of the left leaf of the diaphragm occurring in a 55-year-old housewife is presented.

2. The lesion was successfully resected with recovery of the patient.

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HYPOTENSION FROM ARFONAD: AN AID IN THE SURGICAL TREATMENT OF PATENT DUCTUS ARTERIOSUS IN OLDER PATIENTS

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A METHOD of producing hypotension from Arfonad makes the surgical treatment of patent ductus arteriosus in aged patients more safe.

Hypotension is easily controlled by a single anesthetist by regulating an intravenous drip of a solution containing Arfonad. Controlled hypotension causes the vessels to become flaccid and more easily and safely manipulated. Hypotension produced in this manner by Arfonad is without apparent serious side effects.

This type of surgery has been more difficult in older patients than in children because of loss of elasticity of large vessels, atheromatous changes, loss of tubular structure of the ductus, and a higher blood pressure. The combination of these conditions make it technically more difficult to divide and suture the patent ductus arteriosus in patients in the third and fourth decades.

Groves and associates have used hypotension produced by the method of Gardner and Hale at the Cleveland Clinic Foundation to aid in the surgical treatment of a large or complicated patent ductus arteriosus.[1] This method of lowering the blood pressure is performed by bleeding the patient until the desired state of hypotension is reached. The blood is taken from a peripheral artery and is replaced in a similar manner as necessary at the termination of the procedure. This method has much to commend it, but is a little too cumbersome to use for hypotension needed for only short periods of time. The procedure also necessitates a trained individual besides the anesthesiologist to aid in regulating the level of hypotension. Equipment is necessary to replace the blood under pressure and care must be exercised to avoid air embolism. Finally, an artery must be utilized for the procedure, which is difficult to cannulate without open exposure of the vessel.

Hypotension produced by drugs obviates these difficulties. Arfonad appears to be an ideal drug for lowering the blood pressure and it has been used in many types of surgery as indicated in a report by Sadove, Wyant, and Gleave.[3] Arfonad is a thiophanium derivative which has the characteristic ganglionic blocking and hypotensive effects of tetraethylammonium bromide.[2, 3]

I have observed a neurosurgical colleague use hypotension produced by Arfonad to facilitate ligation of an aneurysm on a middle cerebral artery. The procedure was striking in that the vessels were seen to pulsate feebly and appeared to have little tension. The ease of handling this type of aneurysm was

The Arfonad used in most of the cases reported in this series was furnished through the kind cooperation of Dr. Thomas C. Fleming of Hoffmann-La Roche, Inc.
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remarkable in comparison to those treated with normal arterial pressure. Of course, the application of this type of hypotension to large vessel surgery was immediately suggested.

CASE REPORTS

CASE 1.—R. W., a white woman, aged 30, complained of shortness of breath, fatigue, and rapid heart action. She had had a febrile illness at the age of five or six which lasted for several weeks, and some years later was said to be rheumatic fever. In high school, a heart murmur prevented her from entering in competitive sports. In 1945, an illness, of which she did not remember the details or symptoms, kept her in bed six weeks. Since then she followed a restricted life, but she had had three pregnancies that terminated in normal deliveries without complications. For one year, there had been a noticeable increase in shortness of breath with mild exertion.

Physical examination showed the pulse to be 90 and blood pressure 120/40. A continuous precordial murmur was present which was loudest in the second left interspace and infraclavicular areas. The heart was active and there was a diffuse apical impulse. There was some cardiac enlargement with the left border of the heart outside the midclavicular line.

A roentgenogram of the chest revealed a prominent pulmonary artery and accentuation of the vascular markings of the lungs. The heart was moderately enlarged with a rounded apex.

An electrocardiogram revealed some myocardial changes, but nothing of diagnostic significance; there was no axis deviation.

Cardiac catheterization revealed a pulmonary artery pressure of 80/40. The right ventricular pressure was 80/0-8. Oxygen saturation studies were consistent with the diagnosis of patent ductus arteriosus.

On Feb. 16, 1954, division and suture of a ductus, 1 cm. in diameter, was performed. This was facilitated by lowering the systemic pressure to 80 mm. by the use of Arfonad for a period of about fifteen minutes. The pressure was allowed to return to normal after the clamps were removed and no bleeding was noted from the suture lines.

The postoperative course was uneventful and an examination on March 24, 1954, revealed a 1.5 cm. reduction in the transverse diameter of the heart. No murmurs were evident.

CASE 2.—P. N., a white woman, aged 38, complained of fatigue and mild exertional dyspnea. A heart murmur since birth restricted her activity. During the last few years she had noted increasing fatigue and some shortness of breath while doing her housework.

Physical examination revealed a blood pressure of 135/55 and a regular pulse of 84. A continuous murmur with systolic accentuation was present at the base of the heart with the point of maximum intensity in the second left interspace. The pulmonic second sound was accentuated. The remainder of the physical examination was essentially normal.

A roentgenogram of the chest showed some left ventricular enlargement and prominence of the pulmonary artery.

Cardiac catheterization studies showed a pulmonary artery pressure of 17-8/10-12. Pressures in the right ventricle were 22-24/2-5. Oxygen samples were consistent with the diagnosis of patent ductus arteriosus.

On March 4, 1954, division and suture of the patent ductus arteriosus was performed. The ductus measured 1.4 cm. in outside diameter and was very short. After the ductus had been dissected, Afronad was given and the systemic pressure was lowered from 140 mm. to 90 mm., systolic. The ductus was clamped, transected, and sutured uneventfully. It was of interest to note that the wall was rather sclerotic and irregularly thickened. The pressure was allowed to return to the normal level after the clamps had been removed (about fifteen minutes total time).

The postoperative course was uneventful and one month later an examination revealed a very satisfactory appearance. The heart size had diminished 1 cm. in transverse diameter as noted on a roentgenogram of the chest.

CASE 3.—F. L., a white woman, aged 23, was first seen in St. Anthony's Hospital because of toxemia of pregnancy and spontaneous abortion. At the time of this hospitalization, enlargement of the heart and a heart murmur were noted. In reviewing the cardiorespiratory system, it was found she had noted forceful heart action for many years but had not given this much thought. She was certain it had become gradually worse and on occasions at night this was sufficient to shake the bed. This forceful beating was accentuated by exercise which also caused shortness of breath. No other significant symptoms were elicited.

Her history revealed severe pneumonia in the first year of life with near fatal outcome. Recurrent respiratory infections had occurred every year and frequent bouts of epistaxis had been present from the age of six years.

Physical examination showed a very slender girl, taller than average. The blood pressure was 150/50, pulse 88, temperature 98.6° F. The carotid arteries pulsated vigorously and there was a slight Corrigan pulse present in the extremities. The heart appeared to be moderately enlarged. A loud harsh systolic murmur was present which continued through the second sound and ended in early diastole. This murmur was loudest over the pulmonic area and left sternal border. P_2 and M_1 were accentuated.

Fluoroscopy of the chest revealed a prominent and somewhat dilated pulmonary artery with rather marked pulsation of the pulmonary artery and hilar vessels. The left ventricle was markedly enlarged.

Electrocardiograms showed hypertrophy of the left ventricle. Cardiac catheterization studies were consistent with a patent ductus arteriosus. The pulmonary artery pressure was 64/40 mm. Hg and a right ventricular pressure was 70/5 mm. Hg.

She was admitted to St. Anthony's Hospital Feb. 12, 1954, and division and suture of the patent ductus was carried out. During clamping, cutting, and suturing of the ductus arterious, Arfonad was administered to lower the systemic blood pressure to 80 mm. systolic. The ductus was conical in shape, measured 1.5 cm. in diameter on the pulmonary artery aspect, and was much wider on the aortic side.

Convalescence was uneventful and a follow-up examination in four months revealed a blood pressure of 118/74. No murmur was evident and the heart was quiet compared to the preoperative examination. The pulse was no longer of a Corrigan type and the carotid arteries did not pulsate markedly.

CASE 4.—J. B., a white woman, aged 38, had known patent ductus arteriosus for at least ten years, but with few symptoms. Six months prior to the referral by her physician, a severe respiratory infection occurred which responded to antibiotics. A cough persisted and was productive of mucoid sputum. The cough was paroxysmal and occasionally the sputum was streaked with blood. About ten days prior to hospital entry, a second respiratory infection occurred with aggravation of the cough. She smoked a package of cigarettes a day which seemed to aggravate the cough.

Physical examination revealed a pulse of 80, blood pressure 130/60. A continuous murmur typical of patent ductus arteriosus was present over the second left interspace and infraclavicular area. An occasional sibilant râle was present.

Roentgenograms of the chest revealed marked prominence of the pulmonary vessels. The transverse diameter of the heart measured 15.5 cm. as compared to a 28 cm. transverse diameter of the thorax.

On May 3, 1955, division and suture of the patent ductus arteriosus was performed with the aid of hypotension induced by Arfonad. The ductus arteriosus measured 1 cm. in diameter on the pulmonary aspect. The intima presented partially calcified plaques.

She was discharged on the tenth postoperative day after an uneventful postoperative course. A follow-up roentgenogram in one month showed some reduction in the size of the heart.

CASE 5.—L. D., a white woman, aged 38, was known to have a heart murmur since an early age. Whooping cough had occurred at the age of six weeks during which there was some cyanosis. After that, she had no further episodes of cyanosis. An occasional

irregularity of the heart had been noted. Coughing began about eight weeks before admission to St. Anthony Hospital on Jan. 15, 1955. She denied restriction of activity at any time.

Physical examination revealed a pulse of 84, blood pressure 144/70. The heart examination showed a continuous murmur over the second left interspace and infraclavicular areas. Moist and dry râles were audible over both bases.

Arrangements were made for hospital admission, but acute respiratory distress occurred necessitating an emergency admission. There were coarse sibilant râles throughout the lung fields and prolongation of both phases of respiration. It was thought these symptoms were due to an acute obstructive bronchitis superimposed on pulmonary hypertension.

Medical therapy was effective in clearing the respiratory infection and on Jan. 26, 1955, division and suture of the patent ductus arteriosus was performed. The vessel measured 1 cm. in diameter on the pulmonary aspect. Arfonad was used to cause hypotension during the clamping, cutting, and suturing of the ductus. The pressures were brought back to normal during the suturing of the pulmonary side. When the Gelfoam pledget was removed from the aortic suture line, bleeding occurred which necessitated two interrupted sutures for control.

The patient was discharged from the hospital on the eleventh postoperative day. Examination in three weeks revealed a pulsus alternans which disappeared with digitalis administrations. The heart had diminished in size slightly. The subsequent course was uneventful.

DISCUSSION

The changes in the character of the vessels with a drop of systolic blood pressure of 30 to 40 mm. Hg is remarkable. The aorta, which is tense and often bulbous at the site of ductus arteriosus, becomes pliable and almost flaccid and has a feeling of elasticity that is not present prior to the production of hypotension. Clamping, cutting, and suturing of the ductus is done with about the same ease as in a child. Bleeding is minimal from the suture line at the time the clamps are released and as the pressure is brought back to normal levels, no further bleeding occurs.

The pressure is allowed to remain down only during the time of actual clamping, transection, and suturing of the ductus, a matter of some fifteen to twenty minutes, at the most. This time, with the systolic pressure of around 80 mm., is not sufficient to be injurious to the vital organs, a matter for consideration in prolonged procedures. Clinical shock is not evident as the pulse rate remains at the prehypotensive rate.

Arfonad is usually administered intravenously in a 0.1 per cent concentration. The blood pressure drops slowly, at times taking as long as five minutes to reach the desired state of hypotension. The pressure rises slowly after the drug is discontinued. Neosynephrine or a similar vasopressor drug will cause an immediate rise in pressure should the need occur. However, after the administration of a vasopressor agent, it is almost impossible to lower the pressure again by further administration of Arfonad. This point is of practical consideration for vasopressor agents should not be given anytime prior to the use of Arfonad, if this type of hypotension is contemplated.

An outstanding feature is the facility with which the pressure can be controlled by an unaided anesthesiologist. Control is possible by regulating the rate of intravenous flow of fluid containing the drug. As the need for hypotension is very short, this method is particularly applicable to the division

and suture of a patent ductus arteriosus. Complicated problems such as an aneursym of the pulmonary artery, in cases of patent ductus arteriosus, might also be more easily treated with hypotension produced by Arfonad.

SUMMARY

1. More technical difficulties occur in the surgery of patent ductus arteriosus in older patients than in children, and the risk is thereby increased.

2. These technical difficulties are directly related to : (a) loss of elasticity of the large vessels and to atheromatous changes; (b) loss of the tubular structure of the ductus; and (c) a relatively higher pulmonary artery pressure.

3. Controlled hypotension causes the vessels to become flaccid and more easily and safely manipulated.

4. Hypotension is easily controlled by a single anesthetist by the regulation of an intravenous drip of a solution containing Arfonad.

5. Hypotension produced by Arfonad is without apparent serious side effects. Hypotension of 80 mm. Hg systolic for 15 to 20 minutes is sufficiently long for division and suture of the patent ductus arteriosus and of not sufficient duration to be injurious to vital organs.

6. A slow reversal of hypotension is obtained by stopping the administration of the drug and a more rapid reversal is caused by the administration of a vasopressor agent.

7. Five case reports of patent ductus arteriosus so treated are presented.

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PARTIAL RESECTION OF THE CLAVICLE IN THE SURGERY OF PULMONARY TUBERCULOSIS

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VARIOUS methods of dealing with large chronic tuberculous bronchopleural fistulas, empyemas, and subscapular space infections have gained acceptance among chest surgeons over the past few decades. These include extrapleural and Schede thoracoplasties, muscle transplantation, partial scapulectomy, and skin grafting. Occasionally a direct resuture of the open bronchus is said to be successful, and sometimes re-resection has to be done. The problem of obliterating chronically infected tuberculous spaces, either intra- or extrapleural, is complicated by the rigidity of the bony structures of the chest wall and the shoulder girdle. Usually, when a sufficient number of ribs has been removed, overlying the infected space, or a sufficiently large portion of the entire thickness of the chest wall, including ribs, intercostal muscles, and parietal pleura, has been resected, closure of an empyema cavity can be achieved. Similarly, excision of infected material, partial scapulectomy, and muscle transplantation are usually effective in obliterating a subscapular space infection. Occasionally, however, the infected space persists, especially in its uppermost extremity, in spite of all efforts to obliterate it. In two such instances, it occurred to us that the muscles of the shoulder girdle could not fall in against the chest wall, in the case of a subscapular infection following thoracoplasty, or against the visceral pleura and mediastinum, in the case of an apical empyema with large bronchopleural fistulas, because the shoulder girdle was held out from the chest wall by the rigid clavicle. This seemed to prevent obliteration of the infected spaces in each instance. It was decided that resection of a portion of the clavicle, in combination with other procedures, might result in sufficient medial displacement of the entire shoulder girdle to allow healing to take place. Since, to our surprise, both cases were successful, we are reporting them in some detail.

CASE REPORTS

CASE 1.—G. S. K., a 22-year-old Indian boy, was first admitted to the Wanless Sanatorium in 1950, with far advanced chronic pulmonary tuberculosis of three years' duration. He had a large cavity in the left upper lobe, which left artificial pneumothorax had failed to control in spite of a partial internal pneumonolysis. Consequently, a two-stage left posterolateral

From the Wanless Tuberculosis Sanatorium, Wanlesswadi, S. Satara, India.
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thoracoplasty was done, and completed in October, 1951. The wound became infected, and a chronically draining sinus from a subscapular space infection persisted for three years. This sinus, which opened in the lower third of the old posterolateral skin incision, was partially excised or curetted on four separate occasions over the ensuing years, but after remaining closed for a few weeks, it reopened each time. He was readmitted for the third time in March, 1954, and a Lipiodol study of the space showed that it extended well up behind the left clavicle (Fig. 1). The sputum smears for acid-fast bacilli had been negative for years. Culture of secretions from the sinus was not available.

Fig. 1.—Case 1. The chronically infected subscapular space, outlined by Lipiodol, extends well up behind the clavicle.

On March 5, 1954, under Xylocaine epidural block, with the patient lying on the right side, the old scar, sinus tract, and infected space were widely excised. The regenerated bone which formed a wall of the space was quite healthy looking, and no foreign body was found. One quickly got the impression that the large remaining dead space was being held open by the strutlike action of the left clavicle, and that a portion of this would need to be resected. Accordingly, the wound posteriorly was closed around a large rubber tube drain, and the patient was turned over on his back. Using fresh gowns, gloves, and instruments, a 6 cm. portion of the middle of the left clavicle was subperiosteally excised, and the wound closed without drainage. Pathologic examination of the excised posterior sinus tract showed chronic granulation tissue consistent with tuberculosis. Culture was not made.

For two weeks following surgery the patient was given penicillin and streptomycin. The drain was removed on the third postoperative day. The wounds healed completely, and have remained healed for the twenty months since operation that he has been followed. The degree of medial displacement of the left shoulder girdle as a result of the operation, is illustrated by Figs. 2 and 3.

CASE 2.—Y. B. I., a 33-year-old male Arabian patient, was admitted to the Wanless Sanatorium in June, 1951, with far advanced pulmonary tuberculosis, bilateral, of about six months' duration. He had had a 5-rib two-stage right posterolateral thoracoplasty performed in September, 1952, but the sputum remained positive for acid-fast bacilli, and a residual cavity was apparent under the thoracoplasty on radiograms. On March 12, 1954, therefore,

right upper and middle lobectomy, and resection of the superior segment of the right lower lobe were carried out. The postoperative course was stormy, with the development of recurring atelectasis of the basal segments of the right lower lobe. Eventually the patient refused further bronchoscopies and intratracheal aspirations, and a tracheostomy had to be

Fig. 2.

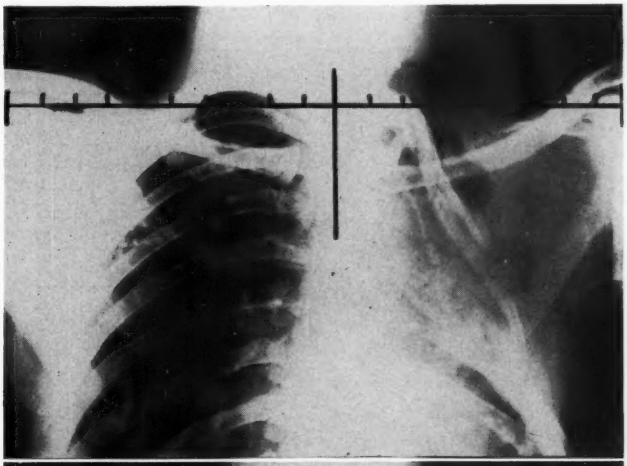

Fig. 3.

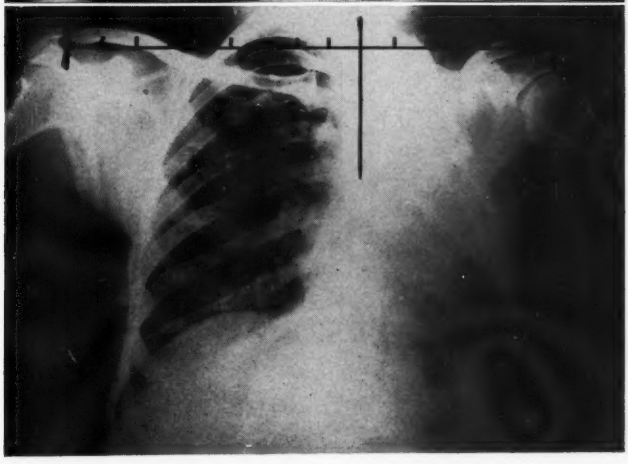

Fig. 2.—Case 1. Chest x-ray before claviculectomy. Each division equals 1.5 cm. The air-filled subscapular space is clearly seen on the left side.

Fig. 3.—Case 1. Chest x-ray following resection of 6 cm. of the middle portion of the left clavicle, showing medial displacement of entire left shoulder girdle, and obliteration of the infected subscapular space.

done to aspirate the right lower lobe. Nevertheless, an empyema and multiple bronchopleural fistulas developed, and open drainage was established three weeks after the resection. In May, 1954, the first of two stages of Schede thoracoplasty was carried out, with resection of the regenerated bony plate from the old thoracoplasty, including the

first five ribs, intercostal muscles, and infected parietal pleura. Two months later the second stage was done, including the seventh through the tenth ribs and underlying structures. A wide-open wound remained, with infected costal cartilages in its anterior depths, a collapsed lower lobe inferiorly, and multiple bronchopleural fistulas superiorly. The scapular musculature could not come medially against the mediastinal pleura because it

Fig. 4.

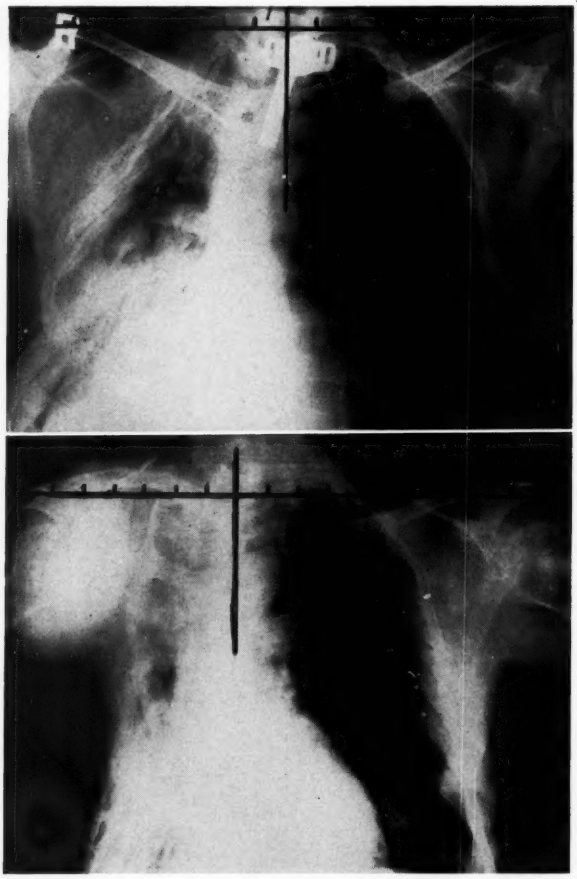

Fig. 5.

Fig. 4.—Case 2. Chest x-ray prior to partial resection of the middle portion of the right clavicle. A tracheostomy tube is in place. (See text.)

Fig. 5.—Case 2. Chest x-ray following partial resection of the right clavicle, showing medial displacement of the entire right shoulder girdle and obliteration of empyema space.

seemed to be held out by the strutlike right clavicular bone. Accordingly, partial claviculectomy was decided upon and carried out in August, 1954, five months after the original resection. At the same time, after carefully draping away the clavicular wound, multiple infected costal cartilages were resected through a separate parasternally placed

incision. A second removal of parasternal infected costal cartilages was done two months later but, by this time, it was apparent that the shoulder girdle was well up against the mediastinal pleura, and that closure could be accomplished of the long narrow but deep posterolateral wound, in the bottom of which three bronchopleural fistulas still were present, though considerably smaller. In January, 1955, ten months after the resection, plastic closure of the large wound was accomplished by transplantation of the subscapularis and latissimus dorsi muscles, and excision of the lower third of the scapula. On a combination of viomycin and cyanacetic acid hydrazide (since he had long since become clinically resistant to the usual antimicrobials, we felt), the wound, which had been drained for about a week, healed up completely, and the bronchopleural fistulas were closed. Some re-expansion of the remainder of the right lower lobe became apparent on x-rays of the chest. The wound has remained healed for the nine months that he has been followed since the last operation. The degree of medial displacement of the right shoulder girdle following partial claviculectomy, is illustrated by Figs. 4 and 5.

DISCUSSION

Claviculectomy, either partial or complete, is usually reserved for tumors, infections, or trauma to this bone, or for gaining access either into the neck or the mediastinum for neurologic, vascular, or thoracic surgical procedures. We found only one report of claviculectomy as an adjunct to surgical collapse of the chest wall in the literature of the past ten years, and no reference to it in any of the standard thoracic surgical textbooks. Lambert,[1] in this Journal, in 1946, reported three cases of tuberculous empyema following pneumothorax, which had persisted in spite of open drainage, Schede thoracoplasty, pack, partial scapulectomy, and phrenic crush. Following partial claviculectomy, two of his patients were discharged from the hospital with small draining sinuses, and one patient died of generalized disseminated tuberculosis two months after the operation. These cases were treated before the appearance of streptomycin, para-aminosalicylic acid, and isonicotinic acid hydrazide. Since these potent antimicrobial agents have become available, the number of times that problems arise in which claviculectomy might be indicated must surely be much less than formerly. That other surgeons are occasionally resorting to this procedure still, however, is evidenced by a personal communication from Dr. J. D. Murphy,[2] who reports two partial claviculectomies done at Oteen, North Carolina, for similar problems. Both patients were reported to have done "exceedingly well, with practically no impairment of shoulder girdle function."

The technique we followed was much like Lambert's. We have, of course, used separate drapes, gowns, gloves, and instruments for resecting the clavicle when a combined procedure was planned, in order to prevent the clean clavicular wound from becoming contaminated. The skin incision, made over the middle half of the clavicle, is deepened through platysma muscle and periosteum down to bone. The middle 6 or 7 cm. of bone is stripped of periosteum and resected, the Gigli saw being a useful tool for this purpose. We have not found it necessary to resect as much of the clavicle as Lambert reported doing. After reapproximating the periosteum, and the platysma, the skin is closed without drainage. Local anesthesia was used in both instances.

Considering the extensive chest wall surgery carried out on both of these patients, dysfunction of the involved shoulder girdle has not been marked, in either case.

SUMMARY

Two cases of pulmonary tuberculosis are reported, in whom long-standing infected subscapular or empyema spaces, complicated in one by the presence of multiple bronchopleural fistulas, were successfully obliterated, with complete healing in both, following partial resection of the clavicle, in combination with sinus excision in one, and Schede thoracoplasty, muscle transplantation, and partial scapulectomy in the other. It is believed that the rigid clavicle occasionally prevents the shoulder girdle muscles from falling in against the chest wall or visceral pleura sufficiently to eradicate the infected space. The procedure is simple, safe, apparently effective, and associated with very little additional shoulder girdle dysfunction.

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EDWARD J. MCGRATH
ARTHUR SHIPLEY

ANNUAL MEETING NOTES

The Thirty-sixth Annual Meeting of The American Association for Thoracic Surgery was held in Miami Beach, Florida, on May 7, 8 and 9, 1956. There were 788 physicians who registered for the scientific sessions. In addition there were 125 wives present.

Following discussion over a period of two years, the Association has now employed Miss Ada Hanvey to be the Administrative Assistant. Her duties include the establishment of a permanent address of the Association at 600 South Kingshighway, St. Louis 10, Missouri. Such matters as address changes and other pertinent information should be sent directly to this address.

The following changes in the By-Laws were voted at the Executive Session:

Article II, Section 5, delete last sentence commencing "Such registered guests shall have the privilege of the floor in discussing papers if time permits."

Article VI, Add Section 5, to read as follows: "The Necrology Committee shall consist of one or more Active or Senior Members, and shall be appointed in accordance with the provisions of Article VI, Section 2 of the Constitution. Appointments to this Committee shall be for a one-year term of office. Any or all members of this Committee may be re-appointed to succeed themselves. The Council may, if it so desires, appoint one of its own members to serve as Chairman of this Committee. The duties of the Necrology Committee shall be to prepare suitable resolutions and memorials upon the deaths of all members of the Association and to report such deaths at every annual meeting."

Article VII, Section 2, changed to read—"Annual dues for Active Members shall be $30.00."

Article VII, Section 3, changed to read—"Annual dues for Associate Members shall be $25.00."

A resolution was adopted requesting the American College of Surgeons to make places for three representatives of the American Association for Thoracic Surgery on the Board of Governors.

MEMBERSHIP NOTES

The Council voted to publish again the standards for election to Associate Membership as recommended by the Membership Committee in 1955.

A. Training:

1. Applicants in the United States must have a sound surgical training as evidenced by completion of the American Board of Surgery.
2. Applicants in the United States must further have met the requirements of the Board of Thoracic Surgery. Canadian applicants must have Fellowship in the Royal College of Surgeons of Canada; be qualified in thoracic surgery or have passed the Royal College examinations for certification in thoracic surgery.

B. Professional Work:

1. High moral and ethical standards are required.
2. Applicant should be established in practice in his community or in a teaching position for *at least three years following training.* His professional work must be of the highest quality.
3. The applicant should have a major interest in thoracic surgery.

4. His professional conduct should be such that he has the support of the members of the Association living in the community.
5. The applicant should show evidence of future participation in meetings by making contributions to the medical literature, advancing the knowledge of thoracic disease, and by leadership in furthering thoracic surgery in his community.
6. Certification in thoracic surgery by the Board of Thoracic Surgery or by the Canadian Royal College of Surgeons *in itself does not mean fulfillment of the requirements* for election to Associate Membership. The other qualifications must be met.

C. Allied Specialists:

1. Members of the profession in allied specialties who are outstanding in their respective fields may be elected to membership in the Association according to the desirability for such specialists as determined by the Council.

D. Foreign Applicants:

1. Thoracic surgeons residing outside the confines of Canada and the United States and its territories are not eligible for election to the Association except as Honorary Members.

E. Exception:

1. Notwithstanding the above qualifications, in exceptional instances the Council may recommend for election a candidate who does not meet all of the above requirements.

Honorary Membership was conferred upon Mr. Philip Allison, Ch.M., F.R.C.S., Nuffield Professor of Surgery, Oxford, England.

The following changes in membership status were voted by the Association during its annual Executive Session:

The following Active members were elevated to Senior Status:

Clarence Bird
Emile Holman
William A. Hudson
Robert M. Janes
Richard H. Meade
Herman Moersch
James D. Murphy
James W. Nixon
Dudley E. Ross
Edward S. Welles

The following Associate members were elected to Active membership:

Oscar Auerbach
Theodore Badger
Henry T. Bahnson
Ivan D. Baronofsky
Edward B. Benedict
Harrison Black
Louis H. Bosher
Robert I. Carlson
Max G. Carter
Sheldon E. Domm
William H. Falor
Egbert H. Fell
Edward A. Gaensler
Paul Geary
Orville F. Grimes
Lew A. Hochberg
William A. Hopkins
Elgie K. Johnson
Hollis E. Johnson
Richard King
Harold A. Kipp
Robert Klopstock
Floyd J. Lewis
Clarence W. Lillehei
Saul A. Mackler
Edgar P. Mannix
Gabriel Seley
Arthur J. Vorwald
Paul F. Ware

The following candidates were elected to Associate membership:

Richard H. Adler, Buffalo, N. Y.
John W. Bell, Sunmount, N. Y.
Francis N. Cooke, Miami, Fla.
Philip Crastnopol, Kew Gardens, N. Y.
Frederick S. Cross, Cleveland, Ohio
Alfred M. Decker, Jr., Sunmount, N. Y.
Sanford W. French, III, San Francisco, Calif.
Francis S. Gerbasi, Long Beach, Calif.
Frank Glenn, New York, N. Y.
Allen E. Greer, Oklahoma City, Okla.
Ormand C. Julian, Chicago, Ill.
Frederick C. Kittle, Kansas City, Kan.
Irving M. Madoff, Brookline, Mass.
Robert W. Newman, Knoxville, Tenn.
Andrew G. Morrow, Rockville, Md.
S. Gwin Robbins, Memphis, Tenn.
Raleigh R. Ross, Austin, Tex.
John M. Salyer, Denver, Colo.
Hawley H. Seiler, Tampa, Fla.
George W. B. Starkey, Brookline, Mass.
Frederick H. Taylor, Charlotte, N. C.
William E. Van Fleit, Emory University, Ga.
George R. Walker, Sudbury, Ont., Can.
Harry E. Walkup, Oteen, N. C.
John L. Wilson, Beirut, Lebanon

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